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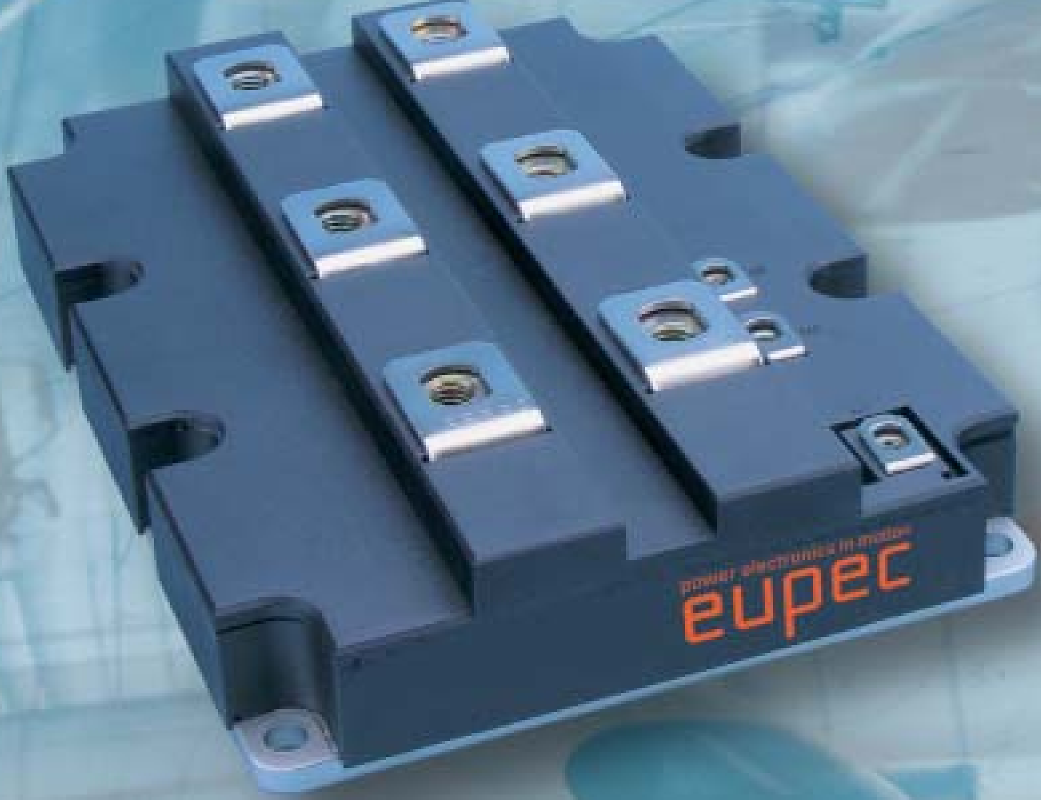
Power Systems Design EUROPE

Power Control Intelligent Motion
November 2004



Trench IGBTs with Field Stop

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Liquid Cooling
EMC in Drives

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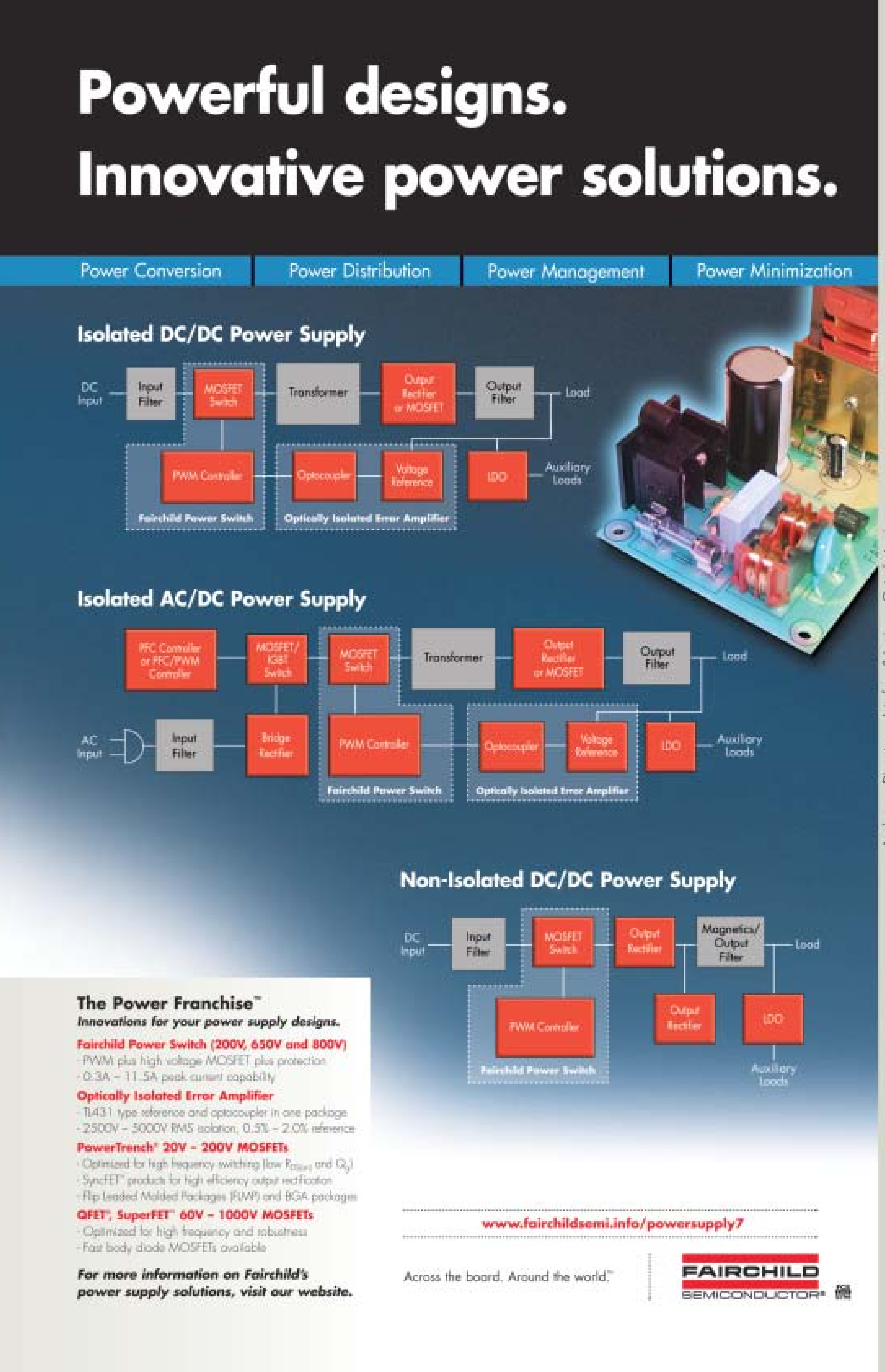

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Advertising Rates, Sizes and Digital File Requirements available at:
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Free Subscription Request for qualified readers

Registration of copyright: January 2004
ISSN number: 1613-6365
Issue print run: 20,000
Printing by: Central - Druck Trost GmbH & Co.
Heusenstamm, Germany

Send address changes to:
circulation@powersystemsdesign.com

Volume 1, Issue 9

The Party will be on, see You in Munich!

A number of encouraging events have me more convinced about the importance of thermal and power management and how it applies to todays technology. Even large display technology depends on chip technology to control and optimize the power consumption.

In the early days, function was the key and heat was the result. TTL logic was able to count for smart power market share based on the power dissipation generated by a logic IC. What a wonderful time we had in the past. Architects took the computer equipment to calculate the heat for warming up the buildings.

Large display tubes occupied a high percentage of office space. Listening to the people at Sharp in a Bavarian Monastery recently showed that flat panel displays would finally overtake the display markets.

Innovation moves ahead and we are looking for less power dissipation in any application. So the switches like MOSFET and IGBT contribute with ever-lower conduction losses and switching losses. We will find ways of operating from device level up to systems level. It is the normal embedded intelligence in systems that count for the next generation of energy savings.

Semiconductors lifetime is a function of operating temperature and cycling, therefore we need to do everything to help keep the temperature cool.

Thermal Management is the key in semiconductor applications. The maximum junction temperature is the leading calculation for worst case situations. Exceeding the maximum junction temperature destroys the device. So the operating conditions must be safe for each of the individual semiconductor devices. Visiting Newcastle about a quarter of a century ago impressed me with the iron bridge built about two centuries ago, an engineering work that reflected the most advanced technology of it's time. Visiting Newcastle today, the millennium bridge, also called blinking eye by the locals, shows what engineering can create today. Here the medium size companies are the innovation motors for the region. Heat pipes made by Thermacore got my attention as they are a smart way to extract the head from the point of generation and spread it in a intelligent way as John Broadband explained to me. I like companies that substantially build the trust for stable growth in the region. A lot in thermals is smart mechanics that need perfected manufacturing. The innovation seeds need to be put into the right topsoil to grow strong and stable. It is my intention to have these companies and products in my radar to serve my readers.

Electronica 9th to 12th of November will be a good place to meet and have the Big Party in electronics. Mark up your calendar for Electronica on Thursday 11th of November in Hall C1 to attend the podiums discussion from 10:00 to 12:00 having the topic "Choose the Right Electronic Power Switch".

I would love to see you putting out the questions to the industry experts in semiconductors from around the globe. That is also a good time to meet me after the podiums discussion to chat.

Maybe I will see you in Nuremberg at SPS/IPC/Drives 23rd to 25th of November. One more of these viewpoints and Santa will come. Believe it or not my childhood is still on for Trains as long as Santa delivers.

Best regards

Bodo Arlt
Bodo.Arlt@powersystemsdesign.com

Thermacore World Class Machining Centre

Thermacore Europe, the Electronics Cooling Division of Modine Manufacturing Co, celebrated the official inauguration of a new state of the art machining centre in their UK factory by inviting local dignitaries and the CEO of Thermacore International to a grand opening ceremony. The centre has helped create new jobs in the area as well as bringing critical value-add technology closer to their customer base across Europe.

The opening ceremony was performed by Councillor Tony Reid, Chairman of the Northumberland County Council. The function was attended by many local and international dignitaries including officials from the NCC, One North East, NECC, Business Link, local universities and business people.

This new machining centre enables the manufacture of complex designs developed by the strong engineering and PhD based Research and Development teams at Thermacore for industry driven thermal solutions.

Chairman of Northumberland County Council Councillor Tony Reid enthused: "Northumberland County Council is extremely proud to be working closely with Thermacore Europe to create and safeguard jobs in the county. The new machining centre is proof that Thermacore is at the forefront of its sector, which can only be good news for employment in Northumberland."

"The new Machining Centre represents a realisation of the importance of bringing some of our high volume sub-contracted activities in house. The centre demonstrates a significant investment in plant, personnel and training. The new centre will enable Thermacore to be cost effective while meeting the challenges of an ever shortening time to market" added Mr Shahab.

Picture: From left to right: Councillor Tony Reid and Arif Shahab General Manager of Thermacore Europe.

www.Thermacore-europe.com

IR's Wales facility receives award for energy efficiency

International Rectifier announced today that its Newport, Wales, facility has earned a national energy efficiency award in the United Kingdom. The facility has won the British Energy-NMI Energy Efficiency Award presented by the National Microelectronics Institute (NMI), a UK industry trade group. The annual award is bestowed on the semiconductor facility that has best exemplified environmental stewardship by significantly reducing its energy consumption and gas emissions, demonstrating best practices for the semiconductor industry.

"I am pleased to present the British Energy-NMI Energy Efficiency Award for 2004 to International Rectifier," commented Derek Boyd, Chief Executive at the NMI. "Since acquiring the site in 2002, IR Newport has reduced its annual energy consumption by 25% while increasing volumes produced by more than 70%. They also have been extremely proactive in engaging other sites in sharing best-practices and have played a leading role in energy management in the UK semiconductor industry," Boyd continued.

On receiving the award, IR Newport's Facilities Director Stuart Langdon said, "Energy efficiency is of paramount importance at IR and winning this award demonstrates our company's commitment. It is an honor to be recognized by our industry body for our achievements at IR Newport."

www.irf.com

www.nmi.org.uk

Fairchild Green Power at electronica

Fairchild at electronica will be showing designers of AC/DC SMPS a complete power portfolio spanning FETs and integrated solutions. New additions to its Green FPS family designed to reduce standby power to below the International Energy Authority's 1W threshold, will be at the centre of its exhibit.

Fairchild is the first and only supplier to provide a complete power portfolio for the full range of AC/DC SMPS designs (high, medium, or low power). Fairchild is the only company to provide a complementing suite of optocouplers, FETs, and integrated solutions to AC/DC SMPS designers. The key announcement by Fairchild at electronica will be new FPS products, that extend the benefits of low EMI, and enhanced conversion efficiency to save power and reduce thermal management issues into a new range of applications.

Alongside its Green FPS family, Fairchild will be exhibiting SuperFET and UltraFET technologies, with world class RDS(on) specifications that allow heat sink size to be reduced. Visitors to the Fairchild stand can learn about Fairchild's Global Power Resource, and discuss their current design challenges with experts from the European Power System labs in Furstenfeldbruck, near Munich. electronica Booth No: A6.233

www.fairchildsemi.com

STMicroelectronics organizational changes

New structure will better match market and technology evolution, while addressing management generational change. STMicroelectronics announced product-group, front-end manufacturing and technology-related R&D organizational changes which reflect the Company's continued emphasis on developing application-specific products and platforms for an increasingly convergent marketplace. The new organization also addresses the retirement and departure of certain of ST's senior executives concurrent with that of its President and CEO, Pasquale Pistorio.

As previously announced, Mr. Pistorio will leave his current position at ST after the Company's Annual General Meeting in 2005 and, with the approval of the Supervisory Board, Carlo Bozotti has been designated to become President and CEO.

All major complex products related to automotive applications, from the present automotive group of TPA and from other product groups of the company, will be consolidated in the new Automotive Products Group (APG), which will be directed by Ugo Carena, who will be promoted to Corporate Vice President.

The Microcontrollers, Linear, & Discrete Group (MLD), will be comprised of most of the present Discrete and Standard Circuits Group's (DSG) products plus standard microcontrollers and industrial devices, and will serve a broader customer base with special emphasis on industrial applications. It will be headed by Carmelo Papa, Corporate Vice President.

www.st.com

Power Events

- ***Electronica 2004***, *November 9-12, Munich, www.global-electronics.net*

Surface Mount 2004, *November 16-18, Brighton UK, www.smartgroup.org*

SPS/IPC/DRIVES 2004, *November 23-25, Nuremberg, www.mesago.de*

embedded world 2005, *February 22-24, Nuremberg, www.embedded-world.de*

APEC 2005, *March 6-10, Austin, TX, www.apec-conf.org*

PCIM 2005, *June 7-9, Nuremberg, www.mesago.de*

EPE 2005, *11-14 September, Dresden, www.epe2005.com*

Industry is Focusing on Perfect Diodes

Diode improvements have made a favourable impact in power supply and drive performance. Silicon Carbide is the future spice for overall improved performance of rectifiers and diodes.

By Bodo Arlt, Power Systems Design Europe, Editor-in-Chief

Bridge rectifiers are available in a variety of packages and configurations in Voltage and Current ranges that serve industry requirements. At 50 or 60 Hertz, the switching losses are not really critical. Rectification of an AC line to DC is one of the most popular duties for diodes. Our focus is set to the more advanced tasks that diodes and rectifier have to perform.

Rectifier usage of today is focused into improvement in rectifier silicon, die size reduction and minimised switching losses. Also, since silicon carbide diodes are commercially available, they are generally for new designs as their switching characteristics show an improvement over silicon-based products.

Lambda power supply has shown the first silicon carbide diodes in power supplies to take advantage of silicon carbide. Industry roadmaps show silicon carbide programs to be a focus, and wafer yields have improved.

Diodes and rectifiers are the basic elements, which can successfully extract the full potential from today's available active switches. As an example in inverter design at line voltages, IGBTs are used along with an ultra fast diode. As compared to the use of a MOSFET with an inherently slow intrinsic diode, the IGBT diode combination is a more efficient solution. As a result, in three phase designs at the required voltage, the IGBT diode is the favoured approach. In discrete devices, the IGBT and diode are in close proximity thus limiting wire length and losses. This approach is very common through out the industry for an optimised switch in inverter design. These combinations are still being used cost effectively today.

The intrinsic diode in the MOSFET is a design burden, a compromise in favour of either conduction or switching has to be made. The compromised designed MOSFETs were used in inverters at line voltage before the advent of IGBT Diode combinations. The so-called Fredfets are found in power supply applications where switching performance at a higher frequency is most critical. Performance improvements in IGBT switching are now challenging MOSFET technology in the higher frequency applications.

Schottky diodes will continue to be used in many low voltage applications as a result of their extremely low forward conduction drop. Currently, the trench-gate MOSFETs is showing significant advantages in improved conduction characteristics in low-voltage applications. Here, the MOSFET is used for synchronous rectification as the extremely low on resistance beats the Schottky diode in DC/DC converter performance. As a result, the MOSFET is favoured in low voltage applications due to an increase in converter efficiency. We are looking at converters reaching 92 to 96 percent efficiency.

A rectifier manufacturer who wants to propose an optimized solution for each function, needs to develop full range with different trade-offs, mainly between forward voltage VF and reverse recovery charges Qrr (or reverse recovery time trr).

So now the entire industry is focusing on perfecting diodes for fast and ultrafast rectification. Designs, which minimize the reverse recovery charge, helped to improve the devices.

Application orientated testing produces the results that indicate that at a higher switching, the electromagnetic compatibility can be confirmed. Finally, the fast and ultrafast diodes have to have a soft recovery characteristic that minimises the EMI.

The name of the game in producing an efficient diode is in the doping process and each supplier has a proprietary recipe. The only Item, which counts, is the performance of the design. Most have shown excellent results as evidenced by the data published in papers, articles and at conferences as well. The rectifier and diode technology and design are not a designer's first choice in the pursuit of circuit elements but necessary. Independent module and hybrid manufactures have the choice of using optimised diodes that match best their performance in the application.

It is up to the end user to make his selection of choice for the best technical and cost efficient solution.

Application-Specific Power Products

By Christopher L. Rexer, Fairchild Semiconductor

Application-specific products are not just for integrated circuits. They are widely available as power products. The continual need for innovative power products to support the increasing functional performance of today's applications defines these products. The introduction of the voltage controlled power MOSFETs and Insulated Gate Bipolar Transistors (IGBTs) have enabled advanced circuit topologies. Continued improvements of these power devices have resulted in improved application performance and functionality. Power product package enhancements have undergone similar technology innovation.

The power MOSFET development has undergone a number of stages of improvement. The first of these focused on enhancing device reliability and dynamic ruggedness. Device architecture improvements then focused on reducing the MOSFET conduction losses which provided improved performance and die cost reductions.

One of first application specific tuning elements was the inception of lower gate drive, from 10 volts to 5 volts. This allowed the devices to be driven directly from logic level integrated circuits. Increased power supply switching frequencies imposed the requirements for the power MOSFETs to be improved for dynamic performance. Capacitance, gate charge, gate resistance and body diode characteristics have been tuned for reduced dynamic losses. Fast recovery high voltage MOSFETs have been developed to match the needs of the ZVS topologies. IGBT devices have been enhanced beyond the punch-through devices to non-punch through architectures for improved tradeoffs between conduction losses, turn off energy, short circuit withstand time and positive temperature coefficient. The popular Fairchild EcoSpark IGBTs are application-specific devices for the advanced Ignition systems in increasingly fuel efficient vehicles.

The use of the trench power MOSFET architecture has resulted in significant improvements of on-resistance for low voltage devices. Low voltage power MOSFET transistor density has recently jumped ahead the trend of Moore's law with the trench architecture progression. Transistor density as high as 640 million cells per square inch is available in recent PowerTrench products.

In response to increased performance requirements, the MOSFET device designers have developed architectures optimized for both the control and synchronous MOSFETs of this topology. In addition to low on-resistance, the control MOSFET is tuned for low gate charge. Improvements have been achieved through process and design features such as trench width and trench density tuning, thick bottom oxide in the trench structures and detailed channel engineering. As a result, the figure of merit (FOM) values of on-resistance multiplied by gate charge have been reduced by more than half in the past five years.

The synchronous MOSFET is optimized for very low on-resistance and shoot through immunity. These are achieved with design features to increase the transistor density and the monolithic implementation of a schottky rectifier with the trench MOSFET. This architecture is realized by the SyncFET products and provides both the forward and reverse characteristic benefits of a schottky diode. With the end application product size decreasing, the need for smaller packages found the power product designers using IC packages. Removing heat, reducing package resistance and package inductance reductions have been areas of performance enhancement.

The MOSFET BGA utilizes a ball grid directly on the power chip which enables direct chip board attach. Combining the appropriate power chip with the appropriate package results a technical solution that is specific to a particular application. The multi-chip solutions of the Fairchild Power Switch, Smart Power Module and Smart Power Switch apply the application specific model one step further.

The performance advantage of power devices has evolved such that there is a now wide portfolio of products available to the power circuit designer. To meet the demands of key applications, a match of unique power device architecture and new package offerings provides an 'application specific power product'. The end result for the circuit designer is improved circuit performance such as converter efficiency, reduced motor drive losses or reduced size of an ultra-portable product. Application specific power products will continue to be developed and implemented into new circuit topologies. As such, the number of device and product offerings will enable new features for the explosion of new electronic products.

www.fairchildsemi.com

3rd Generation 3.3kV IGBTs with Trench plus Field Stop

A new step forward in devices technology

The IGBT3 technology which combines the trench cell and the field stop concept is successfully introduced into eupec´s 1200V, 1700V and 600V IGBT product spectrum. Now the same technology will be adapted for the specific needs of 3300V IGBT applications.

By Thomas Schütze and Jürgen Biermann, eupec

Diversity of application requirements

Application conditions for 3.3kV devices could diverge widely. Operation at low switching frequencies around 200Hz targets to replace GTOs while there are also trends to go up to more than 2000Hz in resonant applications. Some converter designs show stray inductances of less than 80nH, others reach values of 350nH per module. This wide range of operation conditions makes it difficult to find an appropriate trade-off between on state losses, switching losses, switching softness, device ruggedness and cosmic radiation hardness which fits to all requirements.

The development of the new 3rd generation 3.3kV devices is based on a combination of trench cell and field-stop (1). Such a new design approach offers the unique opportunity to make use of several design trade-offs and thereby accomodate for today's wide application diversity. The different demands for high frequency applications (low switching losses) as well as low frequency applications (low V_{CEsat} and V_f) have to be aligned with several other operational conditions like high stray inductance (requiring a soft switching characteristic) or high DC link voltage (requiring a soft switching characteristic together with high cosmic radiation hardness). Of course general demands are a high short circuit and switching robustness. An overview referring to the typical application range of high-power converters is given in figure 1.

Influence of technological parameters on the device characteristics

A reduction of on state losses can be reached without any increase of switching losses by lowering the device thickness. But an exaggerated use of this concept, especially in combination with an increased resistivity of the base material for an improved cosmic radiation hardness, may lead to high di/dt values during switching and to a voltage overshoot with such a high voltage slope that it cannot be controlled even with advanced gate drivers. An appropriate trade-off between the design parameters has to be found to avoid this behavior.

The on state losses of the diode have to be aligned to the IGBT, to allow a better over-all utilization of the module in the converter. The new diode technology combines low on state losses with adequate softness and a high robustness. This combination is reached due to the so called HDR (“high dynamic robustness”) process which is implemented in the new field-stop diodes (2).

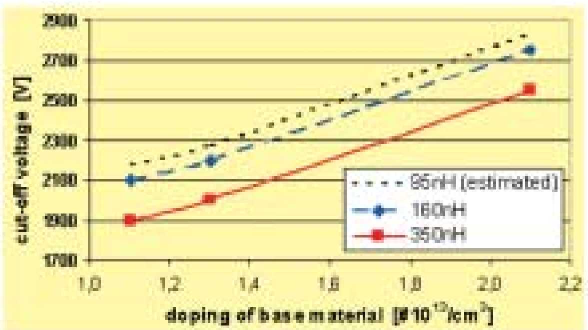

Figure 1. Diversity of application requirements.

Under IGBT turn-off conditions the above mentioned rapid increase of the voltage slope is caused by the field-stop in combination with the stray inductance of the converter. When the electrical field reaches the field-stop layer, there is no minority charge left

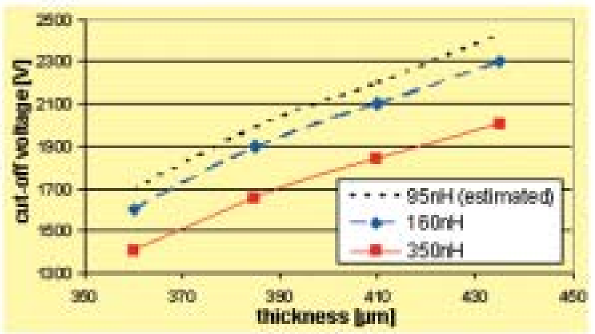

Figure 2. The regime of soft switching behaviour is extended by raising the base material doping.

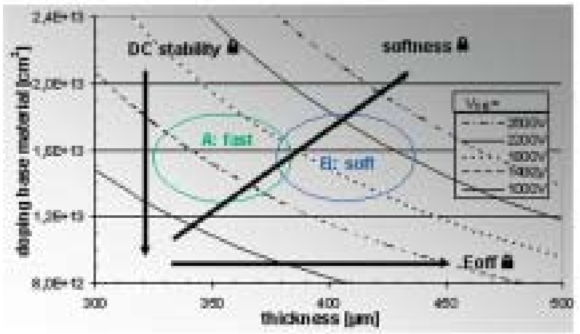

Figure 3. Improvement in IGBT softness by tuning the device thickness.

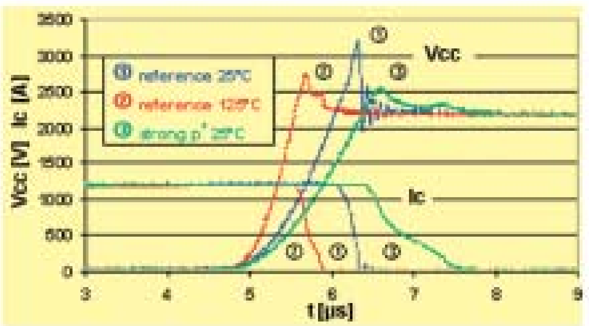

Figure 4. Summary of influence of base material characteristic on device performance.

in the device to be removed and the current goes to zero with a very high current slope. This high current slope leads to a voltage overshoot and to oscillations, which may cause EMC problems. The appearance and amplitude of the oscillations and the height of the voltage overshoot are dependent on the stray inductance of the converter.

One way to improve the switching softness of devices is to shift the voltage, at which the electrical field reaches the field-stop, to higher values. This can be either realized by increasing the wafer thickness or by increasing the doping of the base material. A bigger wafer thickness is leading to enhanced on state and switching losses and furthermore has a negative impact on short circuit ruggedness.

Field-stop devices are inherently more susceptible to a current cut-off compared to NPT devices. A lot of investigations were necessary to obtain a vertical structure that combines minimal switching losses with soft switching characteristics. To find the right compromise on the trade off curve from switching losses to softness is the challenge. The "cut-off" voltage is defined as the V_{CC}-value above which voltage overshoot due to snappy tail current behavior ("current cut-off") is observed.

Figure 2 shows the correlation of cut-off voltage vs. dopant concentration with typical values for 3.3kV devices. As a measure for the IGBT softness the above defined cut-off voltage is used. The stray inductance of the converter strongly influences the switching characteristic as well. The diagram shows the values for typical up to worse case converter stray inductances.

Figure 3 gives an idea of the influence of silicon thickness. If the thickness of the n^- - base material in a field-stop IGBT is raised by an amount of 80µm the cut-off voltage can be lifted by 600V to higher values. For a comparison the standard NPT devices show no cut-off effects even at 350nH stray inductance and a DC-link voltage up to 2200V. By increasing the thickness a similar behavior can be reached with a field-stop device as well.

The extension of the space charge region in the n^- - zone can be calculated exactly for the static case. The height of voltage VCE at which the static electric field reaches the field stop layer is also a measure for the softness under dynamic commutation conditions. It is desirable to have a design at which the field stop layer is only reached at comparatively high voltages. The combined influence of both base material parameters - thickness and dopant concentration - is graphically depicted in figure 4.

Dopant concentration and device thickness are plotted on y- and x-axis respectively so that each position in the xy plane reflects a possible adjustment of the bulk material used in the IGBT. The influence on device characteristics like DC-stability, turn-off energy and switching softness is indicated by the arrows. A qualitative evaluation of the performance in terms of softness is given by the lines referring to specific values of the voltage V_{CE} at which the field stop layer is reached under static conditions.

Another way to improve the switching softness is to increase the backside emitter efficiency of the device. This influences the switching softness in two ways. First, the carrier concentration near the backside of the device is increased. This additional charge prevents the current from abruptly going to zero. Secondly, an increased number of holes, which are moving through the space charge region during turn-off, adds to the doping of the base material and therefore prevents the electrical field to penetrate into the field-stop layer when voltage builds up across the device.

The transient turn-off behavior for a reference sample with moderate backside doping is given in figure 5 for two temperatures: Especially at room tem-

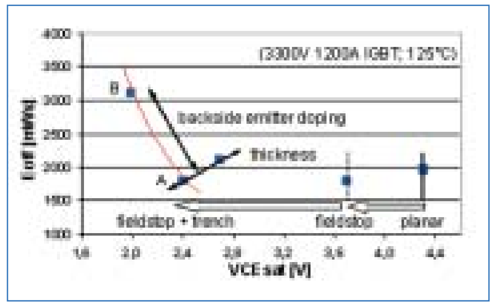

Figure 5. Influence of backside p+-doping or temperature on turn-off softness.

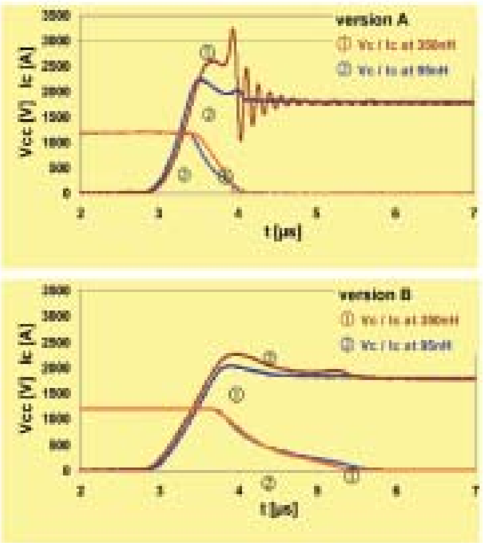

Figure 6. Trade off between turn-off losses Eoff and on state voltage V_{CEsat} at T = 125°C.

perature the penetration of the space charge into the field-stop reflects itself in the rapid voltage rise near the point when VCE reaches its peak value. For elevated temperatures the effect becomes less pronounced due to the enhancement of emitter efficiency by temperature rise.

The beneficial influence of a stronger backside emitter doping is shown by the waveform in figure 5 recorded at T_{vj}=25°C – this is the worse case condition as far as current cut-off is concerned.

Trade-off between on state and dynamic losses

To adapt the switching behavior for applications with high stray inductances the backside emitter efficiency has to be heavily increased. This leads to a decrease of the on state losses, but also to a strong increase of the turn-off losses of the device. Figure 6 shows the trade off between turn-off losses E_{off} and on state voltage V_{CEsat} for today's different IGBT concepts and two different field-stop plus trench optimizations marked "A" (fast, optimized for low total losses) and "B" (soft, optimized for circuits with high stray inductance).

Figure 7 shows the switching behavior for both versions at two different stray inductances. For standard designs with stray inductances <100nH the "fast" version A shows an adequate switching behavior, while it leads to not acceptable oscillations in a high inductive set-up. The "soft" version B that has been achieved by tuning the backside emitter efficiency confirms its usability in a measurement with 350nH stray inductance. Turn-off losses double compared to the "fast" version. Of course the higher switching losses of the "soft" version compared to the "fast" one are partly compensated, when additionally considering its lower on state losses.

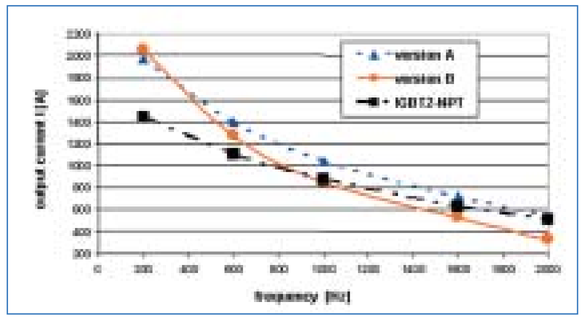

Figure 7. Turn-off waveforms of 3.3kV trench plus field-stop IGBTs designed for low switching losses (version A) and low on state losses (version B).

A comparison of both IGBT3 versions with the standard NPT module is finally given in figure 8. Performing a comparative thermal calculation with T_j=125°C , T_a=40°C and an air cooled heat-sink we achieve improved performance of the fast A version for switching frequencies above 400Hz if compared

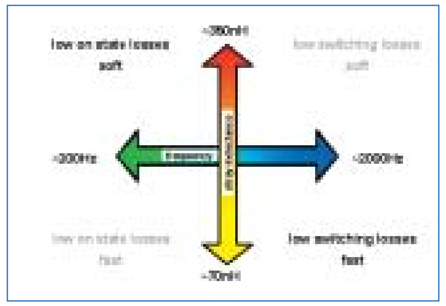

Figure 8. Achievable output current vs. frequency deduced by a thermal calculation. The thermal limits are set by the IGBT: T_{vj}<=125°C and the cooling system T_a=40°C.

to version B. Version A is outmatching the NPT standard across the whole frequency range.

We can deduce a substantial enhancement of up to 40% of the output current capability for inverters built of the new IGBT3 technology against standard NPT devices.

Similar considerations regarding conduction and switching losses as well as softness and cosmic radiation are also applicable for the diode. The new diode structure with optimized field-stop technology and the established HDR principle guarantees the required robust and smooth switching behavior.

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www.eupec.com

A Power Struggle in Power Operating Systems

Battle for control of the POS expected to spur competitive jockeying

By Derek Lidow, iSuppli

A power struggle is looming. The battleground is the emerging market for Power Operating Systems (POSes). The combatants are some of the world's top technology companies. At stake is control of the Approved Vendor List (AVL) and margins throughout the design chains of countless electronic products.

DCP Gains a Foothold

The roots of the present conflict can be found in the advent of Digitally-Controlled Power (DCP). DCP is defined as the use of microcontrollers, Digital Signal Processors (DSPs) and application-specific silicon and firmware for system monitoring, internal and external communication and control of power systems. The technology promises to bring flexibility and programmability to power supplies, leading to increased performance and reliability, while reducing complexity and time to market.

Sales of DCP products in 2004 will generate revenue of just $26.5 million, iSuppli Corp. predicts. However, from this small base, the DCP market is expected to exhibit stunning growth over the next three years and reach $335.2 million by 2007. Figure 1 presents iSuppli Corp.'s forecast for DCP chips. DCP initially has found usage in high-end or enterprise servers. The second stage of DCP adoption involves usage in communications equipment and then to video game consoles, industrial gear, notebook and desktop PCs and automotive systems, iSuppli predicts. However, DCP is only a precursor to a real revolution in power management: the rise of the POS. DCP enables the development of

POSes that will yield significant system-level improvements that cannot be achieved through other means, iSuppli believes.

The Power of the POS

POSes can conduct multiple tasks, including system- and component-level performance monitoring, system configuration, system and component debugging, management of communications bus protocols and real-time parametric programming at the system, bus and power-management component levels. Benefits of using POSes in electronic equipment include:

- Less time to market
- Reduced board space
- Lowered costs
- Greater reliability
- Increased efficiency
- Real-time system-level performance optimization

The Battle for POS Position

The battle over the POS market is expected to be fierce. The design and part selection of electronic systems will be determined largely through requirements dictated by the POS. Thus, the company that controls the POS for a piece of electronic equipment will control that product's AVL as well as the margins throughout the design chain. Because of this, many companies are vying or are expected to make a bid for a position in the nascent POS market,

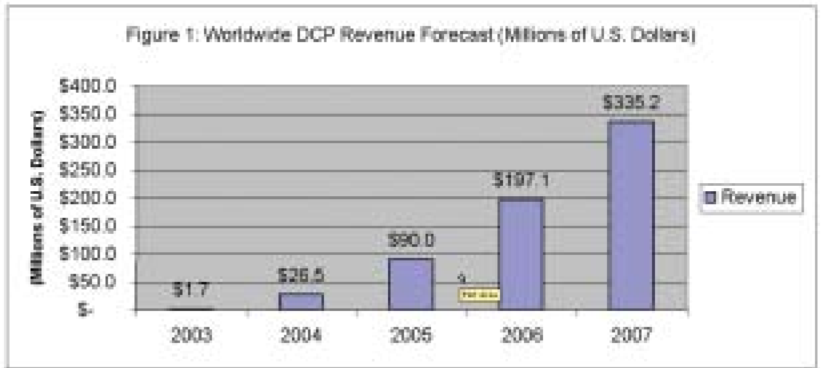

Figure1. Worlwide DCP revenue Forecast (Millions of U.S. Dollars)

including systems integrators, proprietary POS providers, open POS providers, custom power component conversion suppliers and standard power component conversion suppliers. Initial players in the POS market include power-supply providers and component suppliers. Telecommuni-cations OEMs are expected to make their entrance into the market in the future.

However, over the long term, the power battlefield is growing much more complex. The importance of component suppliers will diminish. The leading POS players of the future will include joint ventures between power-management subsystem providers and component suppliers and between telecom system OEMs and power-management subsystem providers.

POS Questions

For each of the combatants in the battle for control of the POS, there is much at stake and key questions to be answered. These questions include:

- Will the groups of OEMs create their own open POS in order to ensure they receive the benefits of shared IP and interoperability?
- Will power-conversion companies be able to establish robust multi-sourcing relationships in order to get control of power conversion architectures?
- Will power-management silicon companies produce the compelling power silicon control and interface architectures needed to capture more margin?

The adoption of POSes will deliver significant benefits throughout the value chain—but it also will bring major disruptions. Control of the POS will strongly determine how value is distributed in the supply chain, spurring furious competition among various players from various industries. Companies in various industries will pursue a range of different business models to achieve success.

For companies throughout the electronics industry, there is much to gain and to lose from implementing a thoughtful and coherent POS strategy.

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Enhanced Current Source Inverter

The fit for low-cost permanent magnet AC motor applications

The permanent magnet AC motor is a staple for designers of HVAC drives as well as fans and pumps for numerous applications. The motors are reliable, based on proven technology, and produced in large numbers at low cost.

By Dr. Velimir Nedic, International Rectifier, El. Segundo, California

The minimum cost of a conventional voltage source inverter drive for a low-cost permanent magnet AC motor is limited by its need for a large electrolytic capacitor. A new current source inverter topology allows designers to eliminate this capacitor without introducing the need for a large DC choke, unlocking further cost savings as well as inherent performance advantages.

The permanent magnet AC motor is a staple for designers of HVAC drives as well as fans and pumps for numerous applications. The motors are reliable, based on proven technology, and produced in large numbers at low cost. Suitable drives are also relatively inexpensive and easily implemented as a voltage source inverter (VSI) with a diode across the output. The only drawback of the VSI is its need for a large electrolytic capacitor. As well as limiting the lifespan of the system, this is itself a relatively expensive component. Eliminating this capacitor, for example by switching to a current source inverter (CSI), would allow a further cost reduction.

To achieve this successfully demands some changes to the conventional CSI topology, which places a line-controlled thyristor rectifier at the input and PWM current-source inverter at the output. This arrangement requires a large DC choke.

However, placing a PWM three-switch buck rectifier ahead of a thyristor inverter bridge allows the choke size to be reduced to a size that can easily be embedded into the machine, thereby enabling an essentially inductor-less drive. In addition, the PWM rectifier allows sinusoidal modulation of the input currents and facilitates simplification of the motor starting scheme. The theory suggests this revised topology could deliver a better low-cost solution with improved reliability, lifetime and transient response than the VSI or conventional CSI implementation.

Theory of Operation

Figure 1 shows a block diagram for such an inverter. The three-switch PWM buck rectifier uses charge control, with two charge mode PWM comparators, to achieve sinusoidal modulation of the input currents, even though the DC link current contains high switching ripple as well as a harmonic component at six times the inverter frequency. This allows a very small DC link inductance to be specified. The load-commutated thyristor inverter is current-fed through this small DC link inductor, and enables electronic commutation of a permanent magnet synchronous machine. A small LC input filter absorbs the high-frequency harmonics injected into the AC mains by the rectifier switching action.

The DC link inductor, L_{DC}, smoothes the DC link current. When integrated as part of a permanent magnet synchronous machine, its value should be below the switching frequency limit and permissible DC link current ripple appropriate for the iron losses and saturation conditions in the machine core. The input rectifier effectively makes use of the machine leakage inductances, Lc, to smooth the DC link current. The equivalent DC link inductance, Le, is given by

$$Le = L_{DC} + 2Lc$$

The final stage of the inverter consists of six thyristor switches, which are naturally commutated by the back EMF induced in the machine during normal operation in the same way as a standard load-commutated inverter. Starting is achieved by disabling the rectifier switching so that the current freewheels to zero through one leg of the rectifier bridge, which interrupts the DC link current prior to each commutation.

ELECTRIC DRIVES

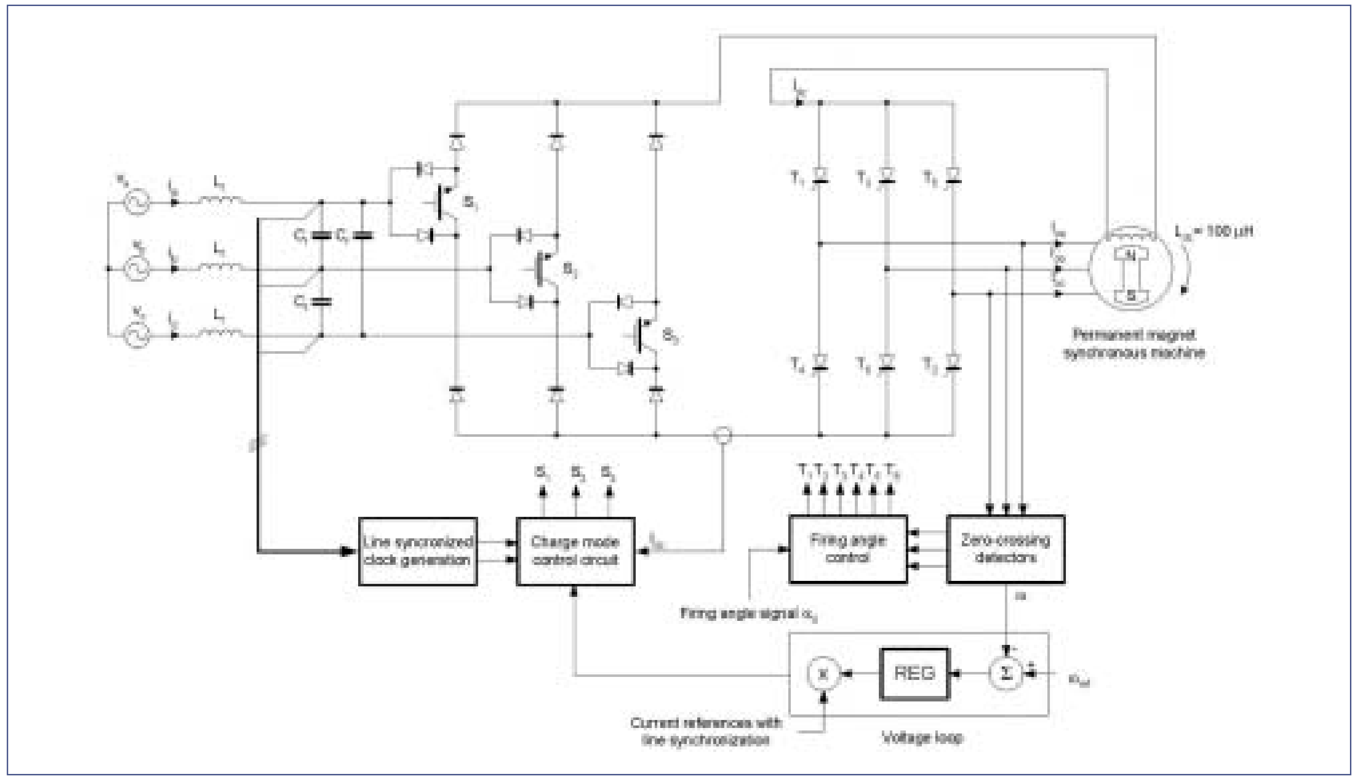

Figure 1. New topology for current source inverter, showing PWM buck rectifier feeding thyristor inverter bridge.

However, unlike a standard load-commutated inverter, only a speed control loop is required since current control is already included in the rectifier charge controller. Also, the speed feedback signal can be derived from the inverter synchronisation, eliminating the need for motor speed sensing. Furthermore, only one sensor for DC link current is required. Inverter triggering signals are synchronised to the rotor position by simple terminal voltage sensing, thereby eliminating position detectors to deliver a further cost reduction without sacrificing precise control of the machine power factor.

The result is a simplified controller that also delivers improved input characteristics and power quality. Compared to a conventional VSI drive requiring six switches and six diodes, the combination of three switches, twelve diodes and six thyristors reduces the BOM cost. But there are some trade-offs. Torque oscillations are higher, and precise position control is not possible. However, thyristor inverters are perfectly suitable for low-cost applications up to several horsepower, and very few of the potential applications for such a drive require precise positioning or speed control.

Optimisation, Simulation and Analysis

Designing the drive requires optimisation of the thyristor firing angle, DC link voltage, DC choke and machine inductances. As the DC inductance is reduced the switching ripple across the machine inductances and thyristors increases. This distortion effectively reduces the thyristor firing margin, requiring the firing angle to be advanced in order to ensure reliable commutation. But since the power factor is approximately equal to the phase difference between the inverter firing angle and commutation angle, a low firing angle is required to maximise the power factor for maximum torque per amp. For this reason, both the absolute and relative values of DC choke inductance and machine leakage inductance have a profound impact on the power and torque available from the motor.

So a trade-off exists in operating the drive system. Assuming that the rectifier output filter is rated only to limit ripple caused by switching modulation, the following equation may be used to evaluate the size of the equivalent DC link inductance:

$$Le = \sqrt{3}Vm / 4fs \times \Delta I$$

where Vm is the amplitude of the input phase voltage, ΔI is the permissible current ripple, and fs is the PWM carrier frequency.

Values for the DC choke and machine inductance can then be derived from the equation:

$$Le = LDC + 2Lc$$

As an example, assume that the maximum permissible ripple in the DC link current is limited to 50% of the rated current. Hence, ΔI = 5A and fs = 7680Hz. The total equivalent inductance should be greater than Le = 2.1mH. Therefore, choosing L_{DC} = 100µH, the machine leakage inductance should be bigger than 1mH.

Based on the above, a machine leakage inductance within the range of 1 to 4mH appears optimal for this drive system configuration. Lower speed machines, which have a high back EMF constant, will require inductance slightly above this range. Machines with a lower back EMF constant will require machine leakage slightly below 1mH.

Results

To investigate and demonstrate the feasibility of this new topology, the complete system was simulated, and the results were compared to the perform-

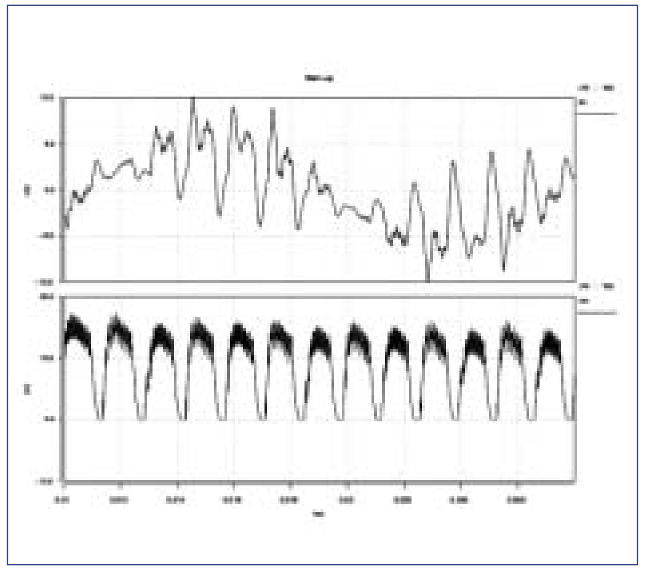

Figure 2 a.

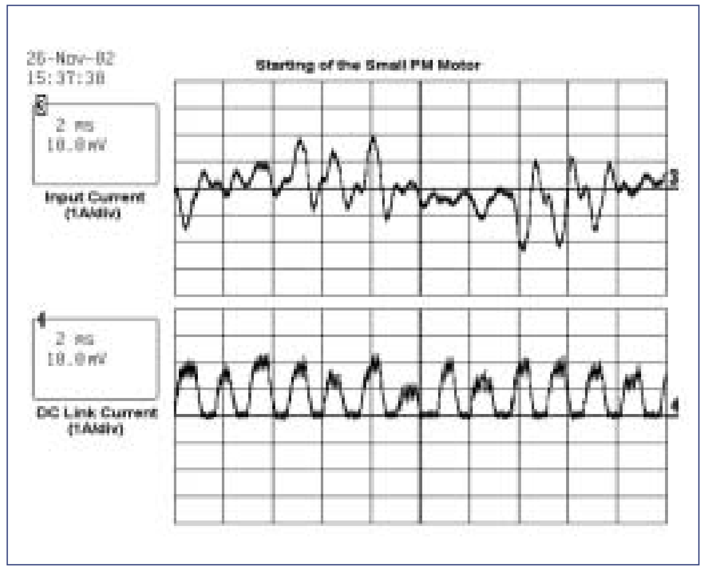

Figure 2 b.

Figure 2 a and b. Simulated and experimental waveforms during starting, showing input phase current above DC link current.

ance of a 3kW laboratory prototype fitted with 100µH DC choke inductance. The prototype was rated for 10A, supplied from a three-phase 230 Vrms line-to-line AC system, and fan-loaded, which is typical for pump applications.

Figure 2 shows the simulated and measured waveforms of the input current and the DC link current during starting. Where the DC link current is interrupted to enable the thyristor commutation, the zero-current interval visible on the bottom trace distorts the input current seen in the top trace. The waveforms confirm that the starting scheme is successful and can be used to accelerate the drive motor.

Figure 3 compares the simulated and experimental results of the input waveforms and the DC link current under steady-state operation. This demonstrates how the input phase current is sinusoidal although the DC link current shown in the bottom trace contains harmonic distortion due to the six-step operation of the inverter bridge and rectifier switching. The low-frequency harmonic components are substantially suppressed, while the unwanted harmonic components are shifted near the switching frequency and filtered out by the LC input filter. Figure 3 also highlights unity input displacement factor operation.

Figure 4 shows the steady-state waveforms of the motor current and the

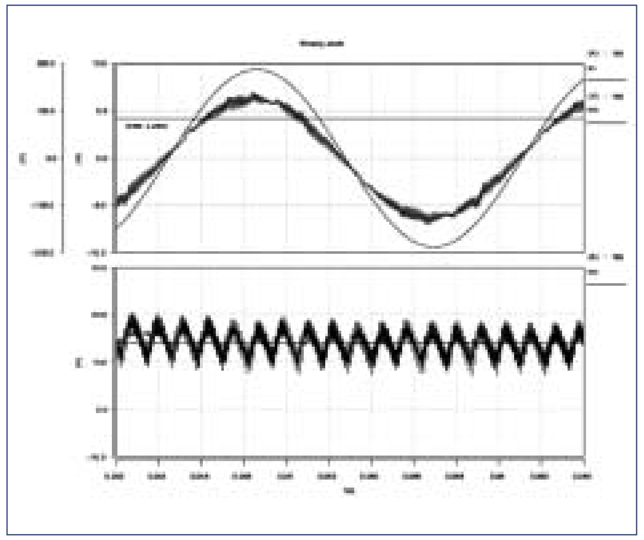

Figure 3 a.

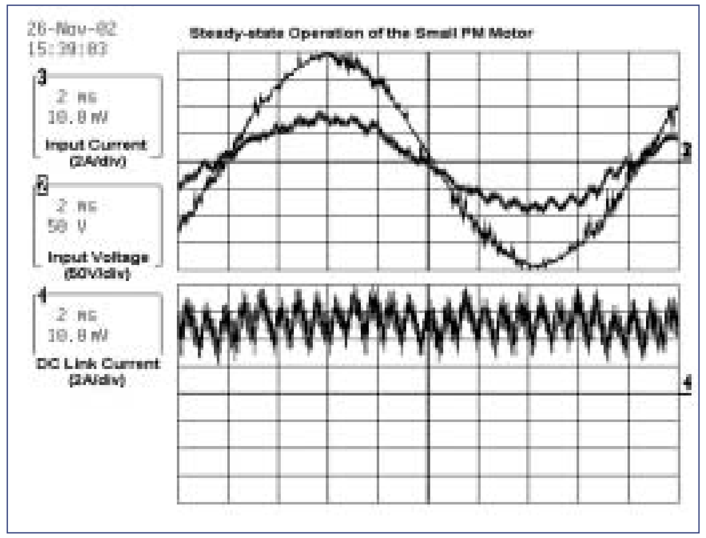

Figure 3 b.

Figure 3 a and b. Simulated and experimental waveforms for input phase current and voltage above DC link current in steady state operation.

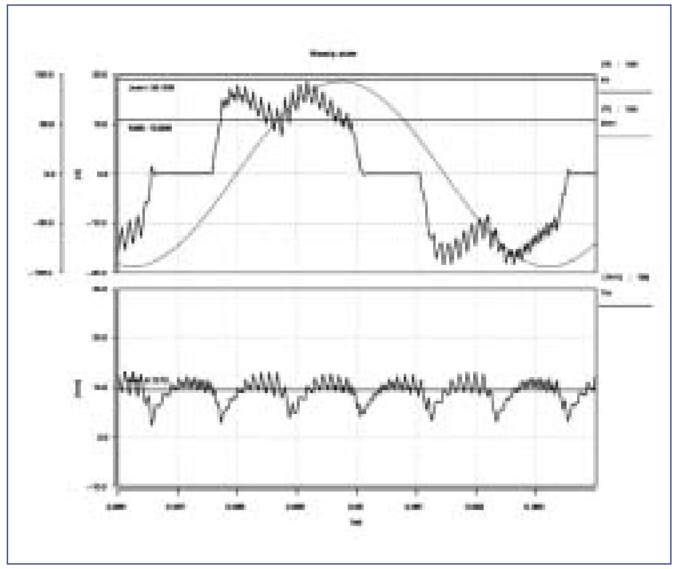

Figure 4 a.

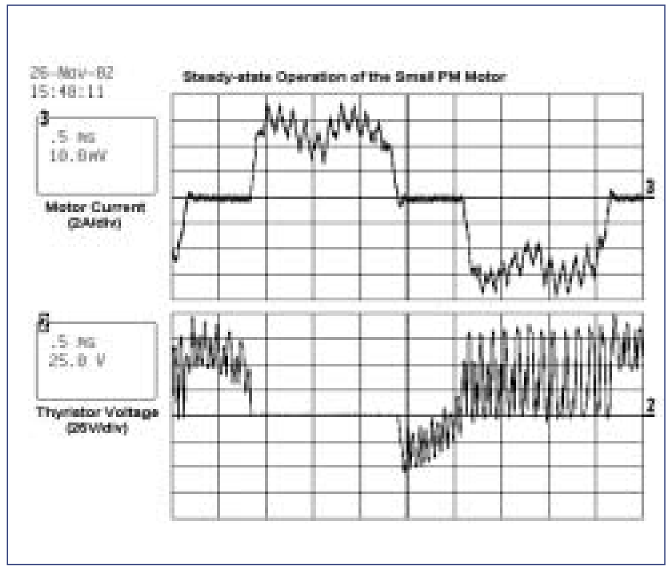

Figure 4 b.

Figure 4. Simulated and experimental waveforms for motor phase current above simulated machine torque (lower left) and experimental thyristor voltage (lower right).

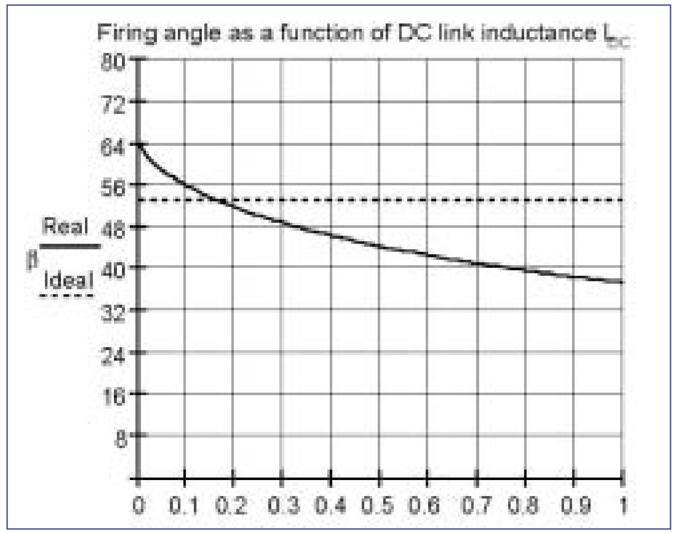

Figure 5 a.

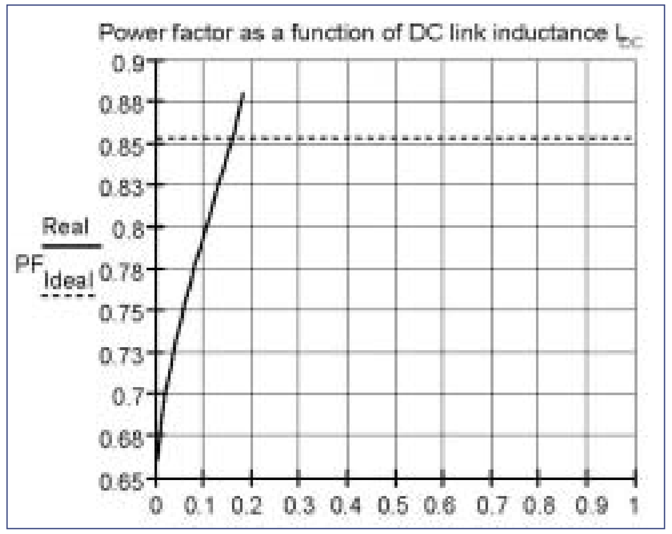

Figure 5 b.

Figure 5 a and b. Inverter firing angle (left) and power factor (right) as a function of DC link inductance.

thyristor voltage during one cycle of the output excitation waveform, with motor speed 3900 rpm and power factor 0.77. The motor phase current contains many harmonics since the DC link current is also distorted. The effect on machine torque is shown in the lower simulated trace. Low-cost applications may tolerate this distortion.

Finally, figure 5 shows DC link inductance as a function of inverter firing angle and machine power factor under the operating conditions defined by figures 7 and 8. Each graph compares the characteristic with that for an infinite DC link inductance. According to the graphs, when Ldc = 100 µH, the machine must be derated about 7 per cent of the maximum attainable power. The graphs also show that for DC link inductance values above 200 µH, the machine can be operated as if an infinite DC link inductance is present.

The ubiquitous voltage source drive is overdue for improvement. A new current source inverter eliminates bulky capacitive storage on the DC link, reduces input current distortion and reduces the number of fully controlled switches required. Simulated and experimental results validate the proposed starting scheme and confirm the expected trade-offs: lower output characteristics, and the loss of precise positioning and speed control. Where the benefits of the low-cost, virtually inductor-less design outweigh these drawbacks, the new topology is a viable replacement for voltage source drive systems.

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The Ever Shrinking Power Supply

The factors driving down the size of AC/DC switchers

Switchers up to 150 Watts tend to use flyback topologies in which the energy is only transferred to the load during the off-time of the switching element. Above this rating, typically forward converters are adopted.

By Steve Head, Marketing Director of XP Power

Changes in power supply design are rarely revolutionary. Rather, they are evolutionary and dependent upon a host of component and manufacturing technologies that, for the most part, develop at a modest pace. Moore's law simply doesn't apply to power supply design; if it did, a 200W switcher the size of a thumbnail would have arrived some time ago. However, even marginally improved versions of some critical components can have a dramatic affect on power supply size. In this article we take a look at the technologies that impact the design of 50W to 200W AC/DC switchers and the contribution each makes to the overall size of the end product. In doing so, I aim to give some guidance to engineers who design power supplies in-house but also to help engineers who specify power supplies from external sources to better understand the solutions they are offered and the potential specification trade-offs that they may face.

AC/DC basic topologies

Broadly speaking, switchers up to 150 Watts tend to use flyback topologies in which the energy is only transferred to the load during the off-time of the switching element. Above this rating, typically forward converters are adopted. In a flyback, the converter can operate in two states: continuous, where the input inductor current does not start at zero at the beginning of the cycle, and discontinuous, where the inductor current starts at zero at the beginning of each cycle. Both topologies use a transformer to provide isolation. In the case of the flyback converter there is only one main energy storage magnetic device, the transformer. In the forward converter there are two, the main transformer and output inductor. Figure 1 shows isolated flyback and forward converter topologies. The largest individual components in such power supplies will be the energy storage capacitors and magnetic components.

Higher switching frequencies enable smaller inductors and capacitors to be used. At relatively high frequencies, less energy per cycle needs to be stored in inductors and capacitors, resulting in

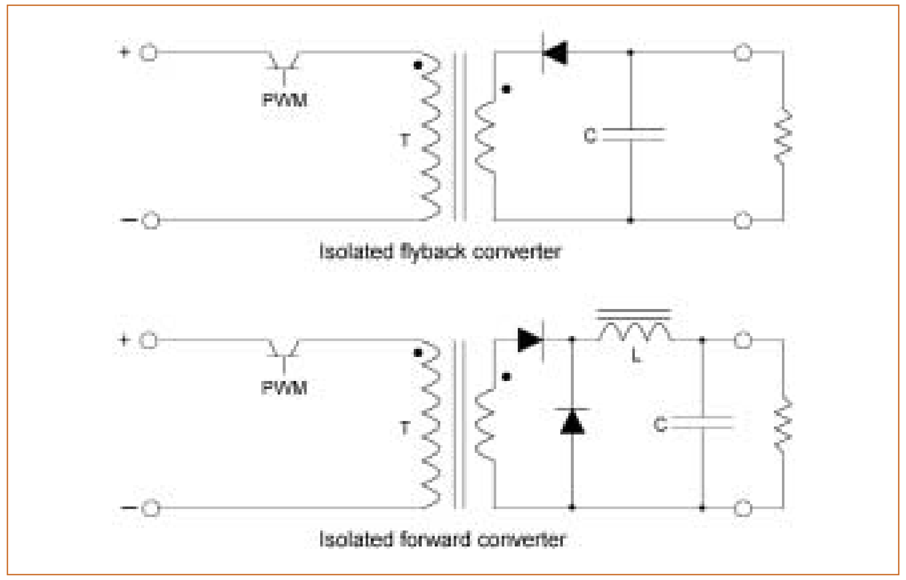

Figure 1. Isolated flyback and forward converter topologies.

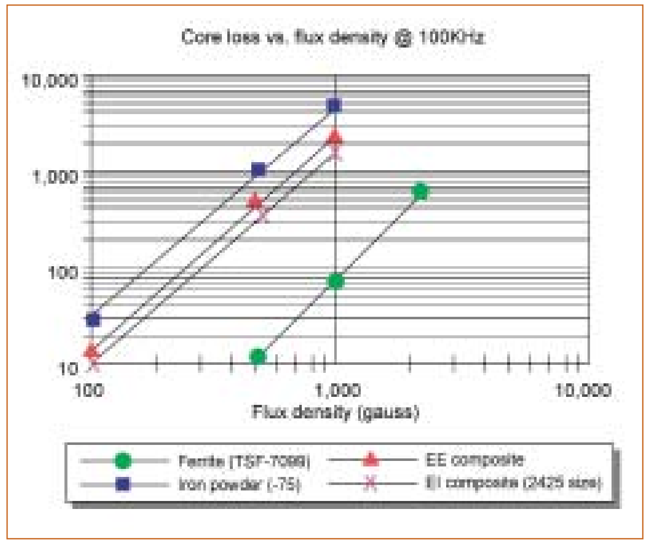

Figure 2. Core loss vs. flux density

lower inductance and lower capacitance values. The trade-off is that switching losses increase with frequency, leading to decreased efficiency. So the practical limit for flyback converters, where energy is stored in the primary of the transformer every cycle, is 100kHz. In forward converters energy is not stored in the main transformer but in the output inductor and practical switching frequencies are up to 200kHz. Of course, low voltage DC/DC converters often operate at 2-4 times these frequencies simply because the relatively close turns ratio of transformers means smaller windings, lower leakage and lower losses, so it's easier to achieve efficient power conversion.

Magnetic components show future promise

In the last few years most improvements in power density have been achieved through advances in semiconductor and capacitor technologies. Looking forward, the most promising developments that will impact power supply design in the near term are in the composition of magnetic cores.

From a power supply transformer perspective, the objective is to find a low-cost core material with enough inductance to store energy, one that does its job with acceptable temperature rise and does not create excessive electromagnetic interference. Powdered iron cores offer the best flux density and magnetic coupling, but are relatively lossy due to the inherent distributed air gaps. Ferrites are efficient, but they are usually too easily saturated to be useful where high energy levels are involved. Gapping the core, with either EI or EE construction, reduces the saturation problem to some degree.

Recent developments in composite cores can help to overcome the disadvantages of both traditional types. For example, in a standard 2425-size core, when one half of the magnetic path length of an iron powder core set is replaced with soft ferrite, losses can be reduced by around 50%. By replacing even more of the iron, reductions of over 60% are possible.

Figure 2 shows the core loss vs. flux density for such a core using iron powder, soft ferrite, and a composite material. Clearly, composites can deliver low losses and high flux density and, by varying their composition, the optimum performance characteristics for a given application can be attained.

Developments in composite magnetic materials will have significant impact on power supply design over the next few years, their take-up being limited only by availability and price. As with most new technologies, availability of composite cores is restricted at present to relatively few suppliers.

Semiconductor on-resistance continues to fall

The on-resistance (R_{dson}) of MOSFETs has fallen by over 75% in the last 5 years, and this is a continuing trend. R_{dson} is a critical parameter in determining the efficiency of the switching circuit, and hence of the power supply as a whole, but even modest reductions often carry a substantial price penalty, particularly if the devices are relatively new and not yet produced in high volume. For example, an IRF 840 with 0.85 Ohm R_{dson} today costs around USD 0.50 while an SPPP20N60 equivalent with 0.19 Ohm R_{dson} is nearer USD 1.30. However, using the SPPP20N60 in a 500 Watt power supply improves efficiency by 2% - a very worthwhile gain. In general, the cost of MOSFETs has fallen rapidly in recent times, so this does mitigate the problem to some degree.

For power supplies with low voltage outputs, 5V and below, synchronous rectification is increasingly utilized. This technique, in which switched MOSFETs replace output rectifier diodes, is now found in power supplies rated as low as 130 W. It results in improved efficiency because, as diode losses depend on I x V_{FD} (where V_{FD} is the diode forward volt drop), paralleling diodes does not reduce dissipation; therefore large diodes are needed at high currents.

Conversely, MOSFET losses depend on I2 x R_{dson} (where R_{dson} is drain-source ON resistance), so splitting current between two MOSFETs reduces each current by 2 and the dissipation in each device by 2^2, i.e. to a quarter, halving the total dissipation and boosting efficiency.

As R_{dson} has fallen it has become less necessary to parallel transistors to reduce the resistance. Using fewer, lower resistance MOSFETs saves board space, but the cost vs. space trade-off needs to be considered for each individual design.

Capacitors improve incrementally and new technologies offer promise for low-voltage circuits

The two primary applications of capacitors within power supplies are high voltage energy storage at the input and low voltage filtering at the output. The input capacitor – an aluminium electrolytic capacitor – is usually the second largest component on the board after the main transformer. The use of active power factor correction (PFC) -

now common on most everything above 200W – reduces the required capacitance 4-fold due to the 375VDC bus voltage. 100µF is the typical value found in a 150W power supply and the active power factor correction circuit takes up little space compared with having to utilize a larger capacitor. The PFC circuit typically takes up the same real-estate as the extra bulk capacitor, but makes the design of the main transformer easier, and reduces its size.

While aluminium electrolytic is really the only practical capacitor technology for the input circuit – nothing else offers the combination of high voltage and high capacitance within a given size - designers are not restricted to this technology for output filtering. Here, a number options are available, but with some limitations on maximum capacitance or working voltage. These include multilayer ceramic capacitors, tantalum capacitors and, most recently, polymer cathode capacitors. Polymer cathode capacitors replace the wet electrolyte in aluminium electrolytics, or the MnO2 cathodes of tantalum capacitors, with conductive polymers. They offer low equivalent series resistance (ESR) and will typically operate at up to 105°C without derating, but the available capacitance values and voltage ratings are still restricted compared with those of conventional electrolytics and there is, of course, a price premium for these newer technologies. However, overall costs have to be considered when single polymer capacitor may replace several aluminium electrolytics because of the low ESR.

The capacitance per unit volume of aluminium electrolytic capacitors has improved steadily in recent years, mainly due to improved etching techniques used on the aluminium foil. Better etching delivers a higher effective surface area and hence higher capacitance for a given component case size. But there have been no dramatic changes.

For both input and output capacitors, the key challenge in minimizing power supply size, while not adversely affecting reliability, is finding components with high enough temperature ratings. Capacitors rated at above 105°C are relatively uncommon, and expensive. Yet most other components within a power supply will operate at up to 125°C or more. Hence capacitors can often be the components that limit the power rating of an AC/DC switcher. Heatsinks for capacitors are available, but they add cost, manufacturing complexity and size to the overall unit, so are not a popular choice.

Years ago relatively few components were available in SMD format, now most are available except larger inductors and capacitors.

The widespread introduction of surface mount components and assembly techniques has been one of the most important drivers in reducing the size of power supplies. It has also enabled added functionality without increases in size by placing control components on the previously unused underside of the board.

Of course, adding complexity and increasing the component count adds cost, but there is increasing demand for control and monitoring signals in power supplies that power critical systems. The additional costs are relatively modest, so most AC/DC power supplies now have integrated DC-OK, remote sensing, and over-current, over-voltage and over-temperature protection as standard. Even though many customers may not use these functions, their cost does not usually lead power supply manufacturers to create multiple product variants with or without such functions. It's not economically viable, so they are offered as standard.

Figure 3. This flyback converter ECM60 is 47% smaller than the previous model.

Hand-in-hand with the adoption of surface mount technology has been the use of multilayer PCBs to provide greater interconnect density for a given board area. Using multilayer boards again adds cost, but the falling cost of other components, particularly power semiconductors, has meant that the cost-per-watt of AC/DC power supplies has decreased steadily in recent years.

As reliability is directly related to temperature, effective thermal management has always been a critical consideration in power supplies. Wherever possible, the use of fans needs to be avoided to minimize cost, size and noise. The increasing availability of thermally clad materials is helping. The PCB itself can be used to conduct heat; heat is removed from both power semiconductors and surface mount devices in this way. However, utilizing insulated heatsinks offers the greatest potential space savings. Multiple devices, at different potentials, can be attached to a heatsink. For example, the power factor correction circuit, power MOSFETs and output rectifiers can all be mounted on a common heatsink. The price is higher than a traditional heatsink but there are savings in manufacturing and the space taken by the single heatsink can be some 30% less than using a number of smaller versions.

A recent new power supply from XP, the ECM60 illustrates the benefits of concentrating design efforts on the critical components within a power supply to minimize size. This flyback converter measures 2" x 4" (50.8mm x 101.6mm) and 1.2" (30.48mm) high - some 47% smaller than the previous model (Figure 3).

Virtually all of this space saving is achieved by reducing the size of the main transformer and replacing through hole with SMD components on back of board. Use of a smaller transformer is made possible through combining discontinuous and continuous mode operation. Discontinuous mode is the more stable from a loop stability standpoint but, since the energy stored is a function of I_{pk}^2, allowing the current to increase so that the transformer goes into continuous mode allows more energy to transfer. Providing the core does not saturate, this technique works well and avoids the need for the larger transformer that would be required for purely discontinuous operation. The ECM60 is designed to eliminate the potential loop instability and saturation problems normally associated with continuous operation. A single MOSFET and standard output rectifier provides the power conversion and two on-board heatsinks are used for cooling. The power supply delivers full power between –10°C and +50°C and will operate at up to +80°C with derating and only 5CFM of cooling. The key factor limiting power to 60 W is the temperature rating of aluminium electrolytic capacitors. These components are so-called 'long-life' capacitors, rated for operation at up to 105°C, but if 125°C rated components were available at reasonable cost, the same power supply could be rated at 80 W output – a further 33% improvement in power density.

Table 1 shows the approximate savings in space that various technologies have enabled in the last 5 years. The savings shown add up to more than 100%, but in reality it is never possible to utilize every size-reduction technique in a single power supply – there are too many trade-offs in terms of cost, manufacturing complexity, and thermal management issues. EMC constraints have to be taken into account too.

Improved manufacturing techniques and falling power semiconductor prices have enabled the cost-per-watt of AC/DC switchers to fall steadily, even while other component prices have risen, and overall complexity and functionality of power supplies has grown. However, the most important thing for power supply designers to remember is that even incremental improvements in the critical components—input transformers, capacitors, and power transistors—can, with creative design, deliver dramatic improvements in power density. It's always worth keeping track of developments in these components.

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Factors leading to reduction in AC/DC power supply sizes in the last 5 years

Technology	Space saving
Smaller magnetic components (due to higher switching frequency)	50%
Better power semiconductors (higher current, lower loss)	30%
Adoption of surface mount components	30%
Improvements in capacitor technology	20%
Use of multilayer PCBs	20%
Better thermal management	20%
Improvements in magnetic component technology	10%
Smaller capacitors (due to higher switching frequency)	10%

Table 1. Savings in space that various technologies have enabled in the last 5 years.

Multi-Output Voltage Regulators

They increase efficiency and reduce system cost

Power management devices must provide multiple voltages, higher currents, better thermal performance, and better fault protection. At the same time, manufacturers are requiring reductions in system size

By Daniel Jacques, Allegro

As the automobile becomes more advanced, the control systems grow in complexity. ECUs (Electronic Control Unit) require robust power management devices, DSPs, and microcontrollers, along with motor controllers, sensors, and communication devices.

Automotive manufacturers are demanding more features, in less space, and for lower cost. These demands are paving the way for up-integrated devices. Up-integration is a design methodology where circuitry traditionally built into separate IC packages, is integrated into a single IC package. An illustration of the concept is provided in figure 1. IC manufacturers choose up-integration because it provides the system designer with options for using fewer discrete components, reducing design time (because the designer can provide a nearly complete solution with one IC), and shrinking system size dramatically. These factors all lead to one result: a cheaper solution. Systems can have fewer components and take less time to design, both of which reduce overall system cost.

Discrete components can be a substantial portion of the total system cost. Systems that have many discrete components and multiple IC's are more expensive and take up more space than an up-integrated IC, and typically does not perform as well as the IC solution. Up-integrated power supplies reduce power dissipation, increase efficiency, and add versatility to the system.

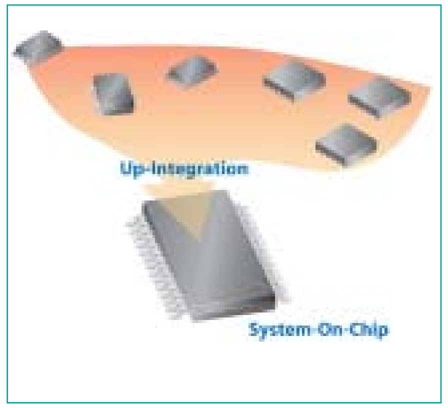

Figure 1. Up-integration methodology allows the consolidation of support devices directly within a single IC package.

For a typical EPS system, it is common to have DSPs, microcontrollers, watchdogs, Hall-effect sensors, and ADCs (Analog to Digital Converters). This is illustrated in figure 2. A system such as this requires both 1.8 V and 3.3 V for the microcontrollers and DSPs. In addition, sensors and ADCs require separate 5 V supplies, and they should track their respective supplies to minimize reference offsets. A solution using discrete devices for all of those components would certainly be expensive, as well as expansive. Providing an IC solution with all necessary voltage outputs, along with additional protection circuitry for fault detection, diagnostics, and system-level controls, not only increases system performance, but also reduces design time and cost.

Efficient Systems Run Cooler and Take Up Less Space

In order to achieve high currents at multiple voltages, it is very important to have an efficient system. Systems in automotive environments need to operate at ambient temperatures of up to 135°C. Linear regulators are good for noise rejection, transient response, and load regulation but, depending on voltage drop across the regulator, efficiency can be very low. In today's 14 V automotive systems, linear regulators run hot and need extensive heat sinking. This will become an even greater challenge with future automotive systems as they head towards 42 V while providing 1.8 V to a DSP. In order to meet present and future automotive requirements, it is necessary to use a hybrid system for power management.

Combining the efficiency of a solid-state switching voltage regulator with LDO (Low –Drop Out) linear regulators provides the best of both worlds. An integrated N-channel buck switch is

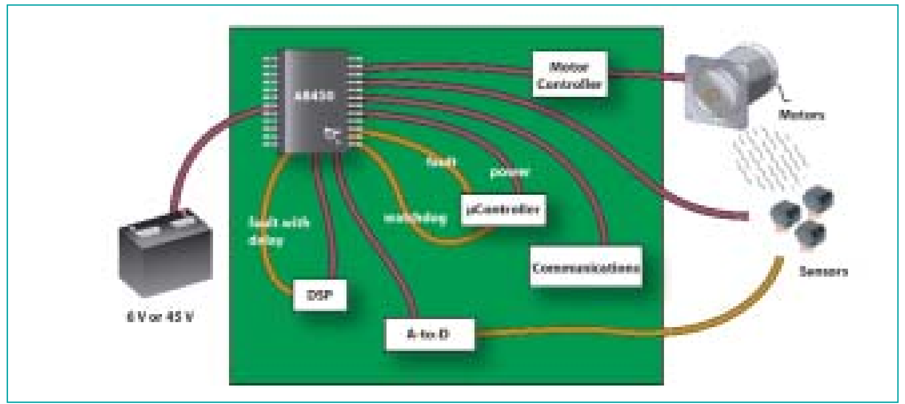

Figure 2. Typical EPS (Electronic Power Steering) application, with the single up-integrated A8450 multi-output voltage regulator.

used for its low resistances and relatively small die size. A charge pump creates a voltage higher than the supply voltage, to enhance turning on the FET, and to provide operation at low input voltages. For example, during cold weather conditions, battery voltages can be as low as 6 V when starting a vehicle. If necessary, the buck switch will implement 100% duty cycle operation to provide the highest possible voltage during cold starts.

Switch mode buck converters can handle an extremely wide input voltage range, from 6 V to 45 V. In figure 3, a schematic diagram representing the Allegro MicroSystems A8450 demonstrates how this is implemented. The switcher steps the battery voltage down to a regulated voltage of 5.7 V plus or minus 2%. This regulated voltage is then used as the supply for LDO linear regulators. By using a very low-resistance MOS device in the switcher, along with LDO regulators, the IC can maintain exceptionally low power dissipation compared to a linear solution. An integrated switcher can be designed to deliver more than 3 A to a load.

To further limit heat generation inside of the body of the IC device, while supporting high-current applications such as DSP voltage supplies, some linear regulators (such as the A8450) provide for the use of pass elements.

In this design, the low-current stages of the regulator remain fully integrated inside of the device body. This includes the control circuitry, fault diagnostics, and protection circuitry. The pass elements are located outside of the IC device. These include the high-current, heat-generating output drive stages of the regulator circuit, such as a power transistor. Efficient thermal packaging can ensure that the pass elements stay cool.

Using external pass elements saves on the quantity of discrete components, because the control circuitry is already provided within the IC. Within the IC, the die area can be reduced because the high-current circuit elements are placed outside the device. Not only does the pass element solution reduce IC cost and power dissipation, but also it is more versatile for system designers because the external elements can be selected for the specific system application.

Keeping Power Supplies Safe From Shorts

Sensors are usually located some distance away from the ECU, making them susceptible to shorts. Wire harness insulation can wear away and expose a regulator output to the chassis of the automobile or to a battery voltage. Short-to-battery and short-to-ground protection are desirable to protect sensors and motor controllers located some distance away from the ECU. Linear regulators can be designed to shut down when a short-to-battery condition is detected, as well as to fold back the current during short-to-ground conditions.

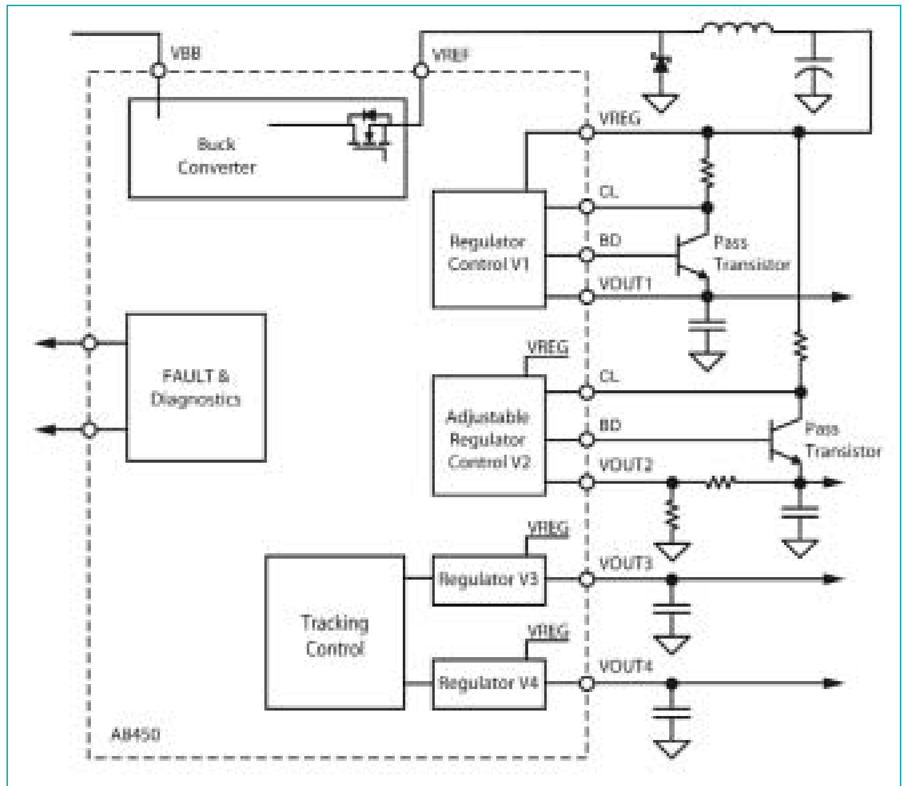

Figure 3. Typical application and block diagram of the Allegro Microsystems A8450.

Regulators that use external pass elements can also be equipped with overcurrent foldback, which protects the external device from overheating. In such designs, an external sense resistor defines the current limit. Upon a short condition, the current folds back to 40% of the set current limit, at zero volts.

In addition to providing protection on all linear regulators, the switcher has a current limit, implemented by reducing the on-time of the switcher. This feature protects the N-channel buck switch from overheating during overloads, or during shorts on the switcher output that supplies the linear regulators.

Providing Information About the System

Diagnostics provide information about the system. When the regulators that control noncritical components are shorted to ground or to supply, or when the die temperature rises to within 15°C of the maximum die temperature, a fault is triggered. An additional fault output is provided if any of the regulators that control the critical components of the system such as a DSP or Microcontroller reach a UVLO (Under Voltage Lock Out) condition. After removal of the fault, the device can trigger the reset of a DSP or a microcontroller, after an adjustable delay.

Power management requirements for automotive ECUs are evolving rapidly. Already some systems integrate several power regulators supporting multiple devices including microcontrollers, DSPs, and sensors.

Greater circuit integration in power management ICs provides the system designer with broader options: multiple linear voltage outputs from a single chip, improved reliability and manufacturability, rapid design for specific applications, and integrated fault detection and reset control. Systems with multiple power regulators that track each other, and are integrated with sensors and ADCs, enable coordinated responses to electrical events.

Up-integrated power management devices prove to be strong additions to system designs, as efficient and affordable options that meet practical design requirements. Buck converters in power management systems reduce power dissipation and accept input voltages from as low as 6 V up to 45 V. In the near future, smaller, thermally-enhanced packages will allow even higher currents and operating temperature ranges.

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EMC in Drive Engineering

Is filtering still contemporary?

The European standard EN61800-3:1996 came into force in 1997 for regulating EMC phenomena in conjunction with adjustable speed electrical power drive systems that are connected to a public low-voltage supply network

By Stefan Melly, Schaffner EMV AG

Amendment A11:2000 to the EMC product standard EN61800-3 for variable speed electrical power drives brought about a number of changes and more precise definitions as compared to the standard published in 1997. Since conformance with the EMC legislation is a decisive selection criterion for most users of frequency converters, drive manufacturers are urged to interference suppress their products in accordance with the prescribed limiting values. An indispensable continuous task, as the next change – prEN61800-3:2003 Ed. 2 with even more stringent requirements – is coming up soon.

The European standard EN61800-3:1996 came into force in 1997 for regulating EMC phenomena in conjunction with adjustable speed electrical power drive systems that are connected to a public low-voltage supply network. To determine the relevant interference voltage limits for the respective drives, criteria such as the environment of deployment of the drive (Fig. 1) as well as the method of sales distribution (restricted or unrestricted) have to be considered.

One of the main negligences of the initial standard was the lack of conducted interference limits for the second (industrial) environment. So for example, in the case of drives with unrestricted availability for deployment in the industrial environment, no interference voltage limits had been defined at all. It was enough to place a warning notice in the user manual and on the drive.

Amendment A11:2000, which has come into force in January 2002, contains enhancements and more precise definitions as compared to the standard that has existed since 1997. With regard to conducted interference, A11 contains a clear tightening of the requirements and not, as is often wrongly assumed, a relaxation of the existing limits.

Now, amendment A11 also defines the limits for the second environment in the frequency band from 150kHz up to 30MHz. A distinction is made according to the rating class of the drive as follows: I £ 100A or I > 100A (nominal input current).

Figure 2 gives an overview of today's limits for conducted interference voltages as defined by EN61800-3/A11 and EN55011. It has to be kept in mind, that the limits for the first environment are also decisive when the source of interference acts in the first environment from the second environment, e.g. if the propagation of interference takes place via the medium voltage network as illustrated in Figure 1.

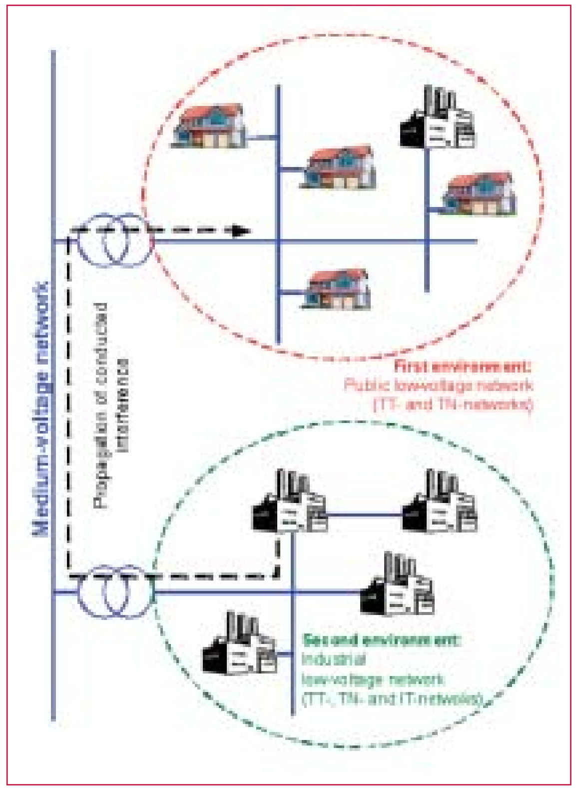

Figure 1. Environments according to EN61800-3

Gazing into the Cristall Ball – Draft Standard prEN61800-3:2003 Ed. 2. At present the product standard for variable speed drives (VSD) is once again subject to revision. Technical voting is closed, a final draft is existing and it is not much likely that the standard will be declined at this point. However, the decision for transition dates is yet missing.

Nevertheless, a considerable number of changes will challenge manufacturers and users of variable speed elecrical power drives once the new standard is established. One of the major changes will be

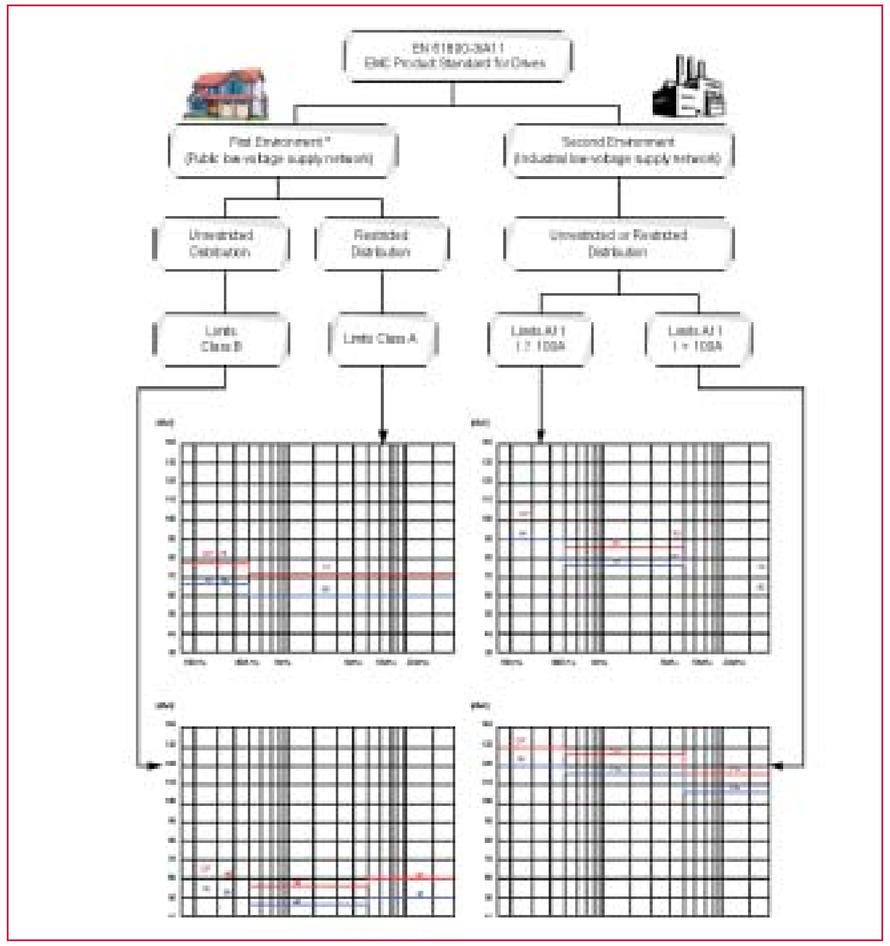

Figure. 2. Selection guide for determining the relevant interference voltage limits.

the replacement of the current selection criterion “method of sales distribution” with the newly defined categories C1 – C4:

- C1 → drives for the first environment with a supply voltage of < 1000V
- C2 → drives for the first environment with a supply voltage of < 1000V (no plug-in, not movable) to be installed by professional technical personnel only
- C3 → drives for the second environment with a supply voltage of < 1000V
- C4 → drives for the second environment with either a supply voltage > 1000V or a current consumtion of > 400A or for “the use in complex systems”

(More details on the expected changes can be found within the pages of the final draft).

By extracting the essential statements from current and future draft standards one will soon realize that there is no sign of relief in EMC matters. When it comes to conducted emissions – despite all attempts to succeed with internal or discrete filtering – an appropriately designed external EMC filter will remain a vital element for the majority of modern drive installations.

However, an additional component must not necessarily be a thorn in the side of manufacturers and users. A properly designed filter will not only guarantee the compliance with rules and regulations, it will also significantly contribute to the reliability and immunity; an arbitrative factor in today’s high density of electronic systems and network integration.

Consequences for the Manufacturers of Variable Speed Drives:

It must be remembered here that numerous users of power drives, especially the small and medium sized companies, installation fitters and small machinery manufacturers do not have their own EMC measurement equipment and EMC specialists. Nonetheless, it is their responsibility to guarantee the reliability and the electromagnetic compatibility of their equipment to the end-user and the government authorities. Therefore, for these companies, it is of utmost importance to purchase products that already fulfill all the applicable EMC standards. Manufacturers of variable speed electrical power drives must be conscious of this purchasing criterion that is becoming increasingly important and it is therefore in their interest to verify the electromagnetic compatibility of their converters and to provide suitable solutions for every possible case of use. To simplify this procedure it is advisable to consign an industry specialist with this demanding task from the very beginning.

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EMI Conducted Analysis with SPICE

Flyback primary supplied by DC from the bulk capacitor

When designing a Switch-Mode Power Supply, the input ElectroMagnetic Interference (EMI) filter is often seen as the most difficult part because simple means are missing to predict the power supply signature.

By Christophe Basso, ON Semiconductor

Electro-mechanical meters have been the standard for metering electricity since billing began. In order to accommodate the advanced requirements not available in electro-mechanical meters, manufacturers have begun adopting all-electronic solutions. New energy measurements ICs (integrated circuits) are enabling accurate, dependable, and robust meters with all the bells and whistles.

Analog Devices has extended its exIf a SPICE simulator cannot obviously give the complete picture, it can certainly help you assess the conducted differential signature and thus let you have a first idea of the input filter size.

Figure 1 represents a Flyback converter whose primary is supplied by the DC voltage stored in the bulk capacitor. This device supplies the high-frequency current pulses whereas the mains refuels it at a low rate via the diode bridge. The primary current shown by the arrow is called the signature of the supply and its shape depends upon many different factors, including conduction mode, switching glitches etc.

To size the input LC filter, one needs to know the level of harmonics generated by the power supply. In a typical EMI laboratory, the SMPS would be supplied by a CISPR-16 compliant Line Impedance Stabilization Network (LISN). The purpose of this network is to a) shield the measurement equipment from any incoming parasitics b) offer a stabilized 50W output impedance from 150kHz up to 30MHz and route the noise to the equipment input. The EMI receiver then sweeps the spectrum of interest and displays the energy content at different frequencies.

SPICE can do nearly the same by implementing an equivalent LISN network and Fast Fourier Transform (FFT). The FFT function of a SPICE graphic processor usually implements the Sande-Tooke algorithm. The algorithm evaluates the harmonic coefficients from an array consisting of a binary radix of data points (128, 256 ...). Depending on the software editor, the processing method can differ, as you will discover below.

During the simulation, SPICE continuously modifies its internal time step to provide accurate results. The time step can either be shorter or longer than the TSTEP variable (in the .TRAN statement), depending on the activities of the computed signals. Generally, the minimum time step cannot drop below 10E-9 times TMAX but this boundary also depends upon the proprietary SPICE algorithm. Without specification, TMAX

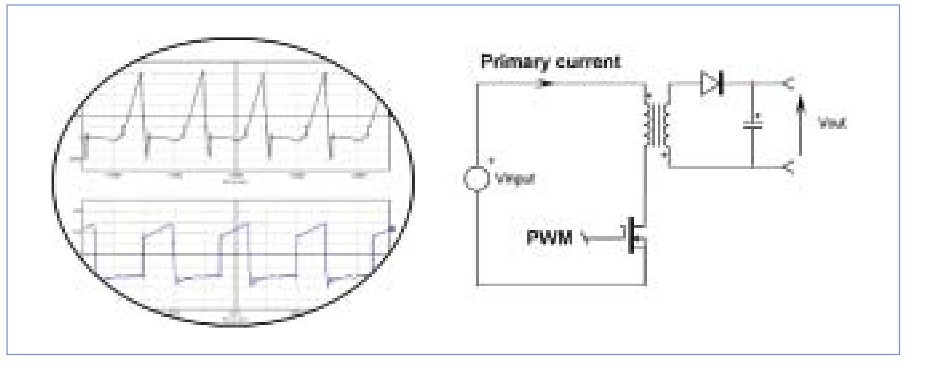

Figure 1The classical configuration of a Flyback converter and possible signatures.

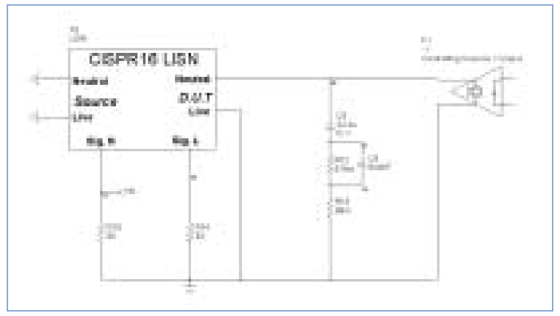

Figure 2. A F1 generator routes the primary current into the bulk capacitor model and then through the LISN.

is fixed at (TSTOP-TSTART) / 50. At the end of the simulation, some SPICE simulators, as INTUSOFT's IsSpice, invoke before storing the data, a linear interpolation algorithm to produce an evenly spaced output at a TSTEP interval. The results are placed in an ASCII SPICE compatible output file that can be examined with the IntuScope investigation tool. However, IntuScope also offers the ability to explore the raw simulated data but furthermore, to re-interpolate them with a different step to let the user change the analysis width. CADENCE's PSpice does not interpolate the data in its .DAT file and the user navigates through the raw acquisitions via the PROBE graphical interface. When the FFT algorithm is initiated, PROBE first interpolates the data to convert the unevenly spaced acquisitions into fixed time step data. It then places the new acquisitions into a data array of the nearest binary radix of points, e.g. 128 locations for a 100 point simulation. The below line gives a possible SPICE TRANsient command you can use to obtain a 30MHz analysis bandwidth:

```
.TRAN TSTEP TSTOP [TSART]
  [TMAX] [UIC]  [optional]
.TRAN 16.6NS 500US 400US 8NS UIC
 ; 30MHz sweep range, 10kHz analy-
 sis BW, 6024 points
```

To test your SMPS SPICE signature, you need to route the current circulating in the input voltage source to the equivalent model of the real bulk capacitor. A F1 source can do the job, as illustrated by figure 2.

Once the simulation has elapsed, a FFT can be run to unveil the harmonic content. The vertical scale is expressed into dBµV by a Log compress of the Y axis to which 120 is added. Figure 3 shows the results obtained using the method.

Without avoiding to run a bench measurement, the SPICE method helps to quickly portray the harmonic content of a given SMPS signature and gives a first idea of the needed differential filter. Example files can be downloaded at: http://perso.wanadoo.fr/cbasso/Spice.htm

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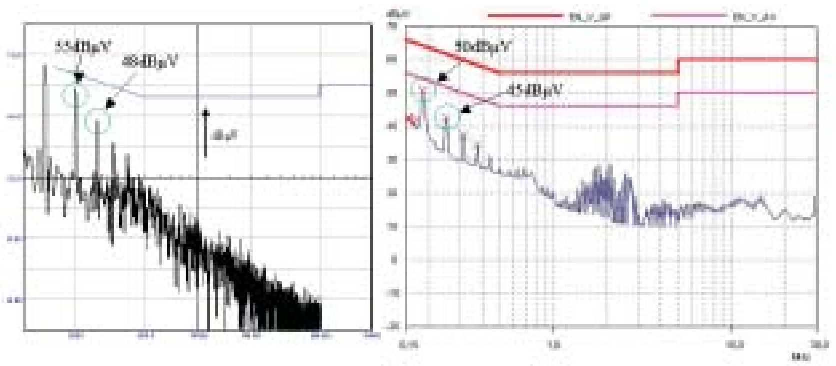

Figure 3. The comparison between the simulation and the true measurement.

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Liquid Cooling in High Density Packages

The better solution for electronics

Moore's law predicted the dramatic increase in circuit density over the last decades. Along with the increase of circuit density, the density of power losses has been increasing. The amount of heat to be dissipated is in the range of several hundreds of watts per sq. cm. for industrial power electronics.

By Dr. Jürgen Schulz-Harder, curamik electronics

The power losses of computer chips are not for away from these values. Technologies like power laser diodes and power LED's are generating even more high density heat. Conventional air cooling is approaching its limits. Liquid cooling can solve many heat dissipation problems. The situation is comparable to automotive engines in the past. Who, for example, still has an air cooled engine in his car today?

The heat paths in electronic assemblies are dependent, in general, on the assembly technology. The main methods used are "chip on board" (COB) or flip-chip. As shown in Fig. 1 for chip on board assemblies the heat flows from the backside of the chip through solder layer 1 and then through the substrate. In flip-chip assemblies the heat is conducted from the top side of the die through a thermal interface material (TIM) and a lid to the outside world. The COB substrate and the lid of the flip chip device must be connected to systems carrying the heat to the ambient. COB technology is typically used for industrial power electronics (MOSFET´s, diodes, IGBT`s), LED´s and laser diodes. Flip-chip technology is the main assembly method for CPU´s, graphic chips and memories as used in desktop and notebook computers

The physical boundary conditions for cooling at the device side are (a) the maximum allowable temperature and (b) the maximum generation of heat per unit area. Fig. 2a shows a simplistic overview regarding heat flux density and operating temperature of different devices.

The highest heat losses are generated by laser diodes, up to 400 W/cm2. These diodes have to be cooled at relatively low temperatures of 50-60∝C. CPU's are moving towards power electronic devices but at lower working temperatures. The values given for LED's are for discrete components. Future SiC chips will have much higher working temperatures and higher maximum heat losses. The physical boundary conditions at the cooler side are (a) the max. heat dissipation per unit of contact area, (b) the ambient temperature and (c) the available space.

Fig. 2b shows also as a very simplistic depiction, where different passive cooling technologies are placed concerning maximum heat dissipation per contact area and necessary cooler volume. Micro-channel liquid cooling has the highest potential for direct cooling without heat spreading at a very low volume/space. Natural convection needs more then 2 orders-of-magnitude more space at low heat dissipation per contact area. The other passive cooling systems are in between these two.

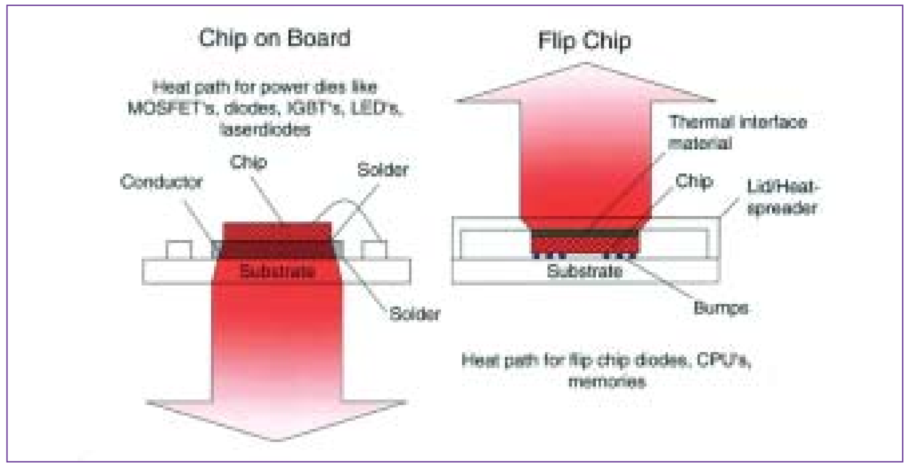

Figure 1. Heat path at COB and Flip Chip assemblies.

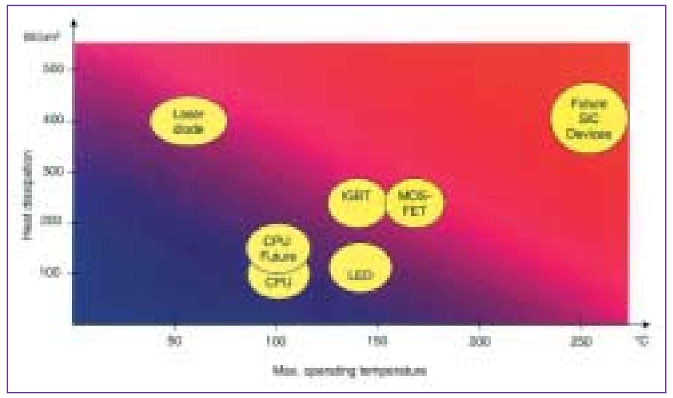

Figure 2a. Overview of heat flux density and operating temperature of different devices.

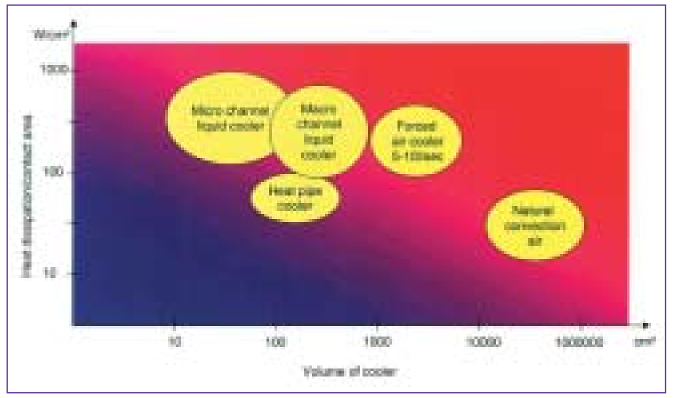

Figure 2b. Overview of heat dissipation capability and cooler volume of different passive cooling technologies.

	Advantages	Disadvantages	Application in electronics
Air cooling	no leakage problems low cost	needs space needs heat spreading high thermal resistance ambient temperature limit noise	wide spread most used technology
Liquid cooling	low space flexible tubing low thermal resistance less noise	additional pump leakage higher price ambient temperature limit	laser diodes power electronics
Heat pipe	low space low thermal resistance less noise	limited heat carrying capacity higher price inflexible tubing ambient temperature limit	laptop computers power electronics aerospace
Compressor cooling	low space low thermal resistance independent of ambient temperature	inflexible tubing high price noise dew point undershooting	experimental for direct cooling indirect Air conditioning
Thermo electric cooling	low space low thermal resistance independent of ambient temperature	limited heat carrying capacity low efficiency	optoelectronics
Thermoacoustic cooling	only one moving part low thermal resistance independent of ambient temperature	not yet commercial technology	experimental for aerospace

Table 1. Several cooling solutions for electronic applications.

The capabilities of passive cooling systems depend on the ambient temperature. Active cooling is not subject to this limitation. There are two additional technologies in industrial applications for electronic cooling: thermoelectric cooling and compressor cooling. Thermoacoustic cooling is reported for experimental space applications.[1] An overview of advantages, disadvantages and applications is listed in Tab. 1.

As shown in Fig. 2a, liquid cooling has the capability to dissipate the highest possible heat fluxes directly at the component. Three examples will be described.

Example 1: Laser diode cooling

Fig.3a shows the construction of a high-power laser diode bar on a liquid cooler. The diode bar is attached to the cooler by a very thin layer of solder. The liquid is flowing into the bottom channel to the end of the heat sink, going up and then back out through the top channel. Fig. 3b depicts the real assembly, Fig. 3c the inner structure.

The single layers consist of precision-etched copper sheets. The copper layers are bonded together by the Direct Copper Bonding (DCB) technology. The temperature distribution at 40 W heat flux and a water flow rate of 0.3 l/min is shown in Fig.4. Due to the very limited space, liquid cooling is the only way for heat dissipation.

Example 2: Power electronics cooling

Fig. 5a and 5b depict a power module where the substrate (AlN) is directly integral with a micro-channel liquid cooler. The inner structure is a hexagonal network made from several copper layers bonded together by the DBC method.[2] [3].

The thermal resistance of this module is only 36% of a comparable standard module mounted on a water cooled plate as demonstrated in Fig. 6. Compared with a standard module on an air cooled heat sink the thermal resistance is reduced by 90%. This particular module operates at 450 A, and can be cooled with water up to 80∞C inlet temperature. The short path of heat flux from chip to liquid allows an essential reduction of space needed for the module.

Example 3: Processor cooling

Computer devices like CPU's, Northbridge and graphic processors have reached 100W/cm² heat generation. For the future 200 W/cm² are predicted.[4] Air/fan cooled heat sinks placed onto the hot components are coming to their limit due to weight, space, temperature inside the cabinet and particularly noise development. Servers equipped with several tens of CPU's are generating several kilowatts of heat that are blown into a room and then the room must be cooled down by a powerful air conditioning system. This system, too, is approaching its limit. Liquid cooling makes it possible to transport the heat to any place where the re-cooling of liquid can be carried out.

Fig. 7 shows a computer cabinet with a liquid cooling system inside, cooling the CPU and the graphic processor. The total heat dissipation is about 150W. Fig. 8 shows the cooler including the fittings for tube connection.

The thickness of the cooler is 3 mm, the weight 51g. The inner design is the same as in example 2 built up by the stacking and DBC bonding of copper

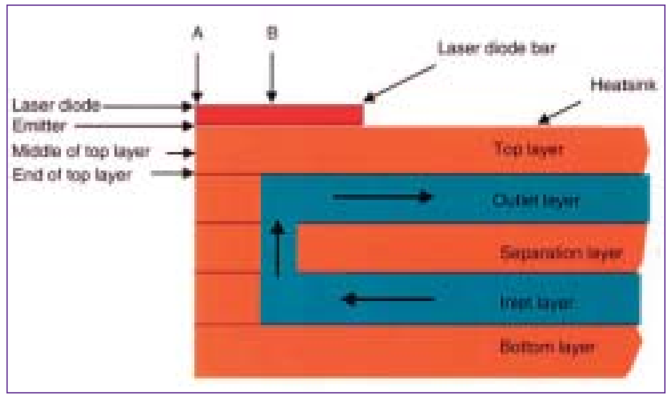

Figure 3a. Cross section laser diode bar on liquid cooler.

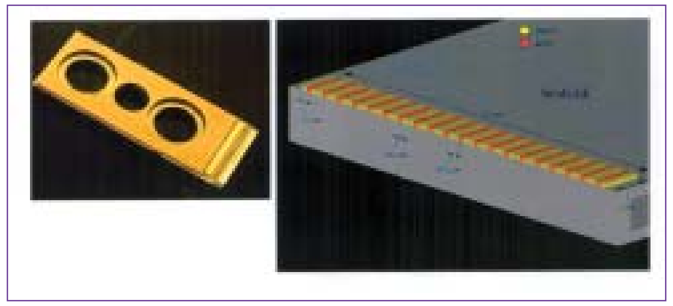

Figure 3b. Assembly of a laser diode bar on liquid cooler.

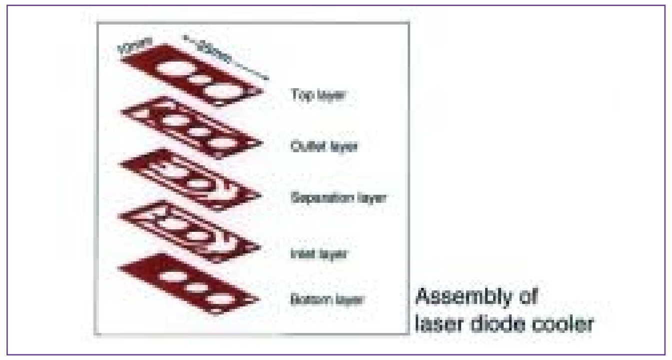

Figure 3c. Structure of laser diode cooler.

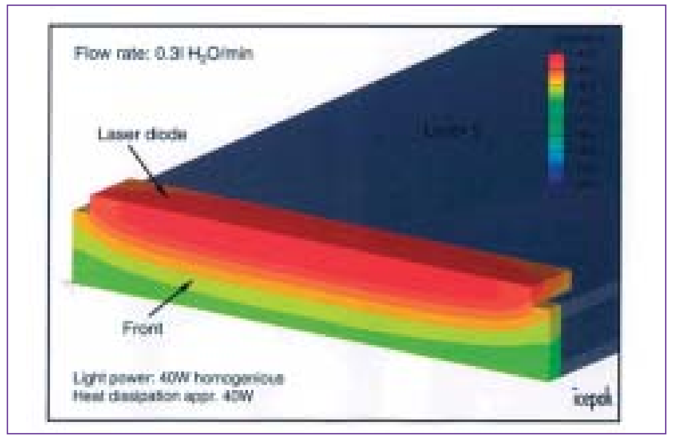

Figure 4. Power laser diode temperature distribution on micro channel liquid coolers.

Figure 5a. Micro channel water cooled module.

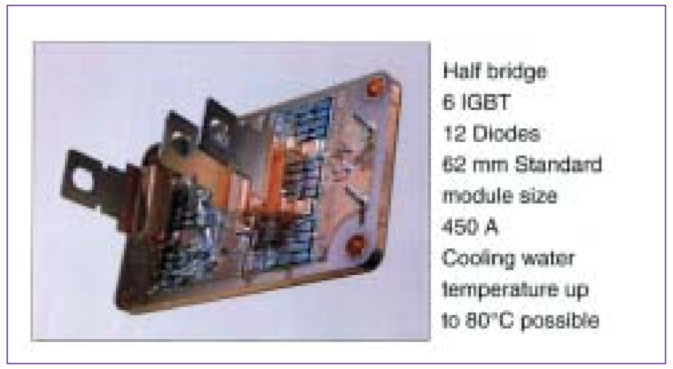

Figure 5b.Micro channel water cooled module.

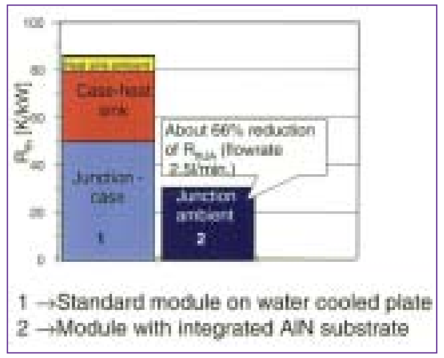

Figure 6. Comparison conventional water cooled and integrated water cooled module.

layers. The thermal resistance is lower than the resistance of the cooler in example 2 due to having no isolating ceramic layer.

Advantages of this system are:

Noise < 25 dBa; Weight on board reduced by 70-90%; No thermal limits up to 150W

The advanced solution is a combination of liquid and active cooling. The performance of passive cooling depends on the temperature difference between the heat sink and ambient air. Passive cooling heats the ambient air. Fig. 9a shows the heat path for conventional cooling systems where the heat sink is placed on top of the component. The inside of the cabinet is heated up and this hot air heats up the ambient air in the room. Cooling down of the air in the room takes place by fresh air from the outside coming through windows or by air conditioning. In this sense you can call the atmosphere an "infinite heat sink".

The next advanced system is liquid cooling of the component and re-cooling the liquid by an air/liquid heat exchanger

Figure 7. Computer cabinet with liquid cooling system inside.

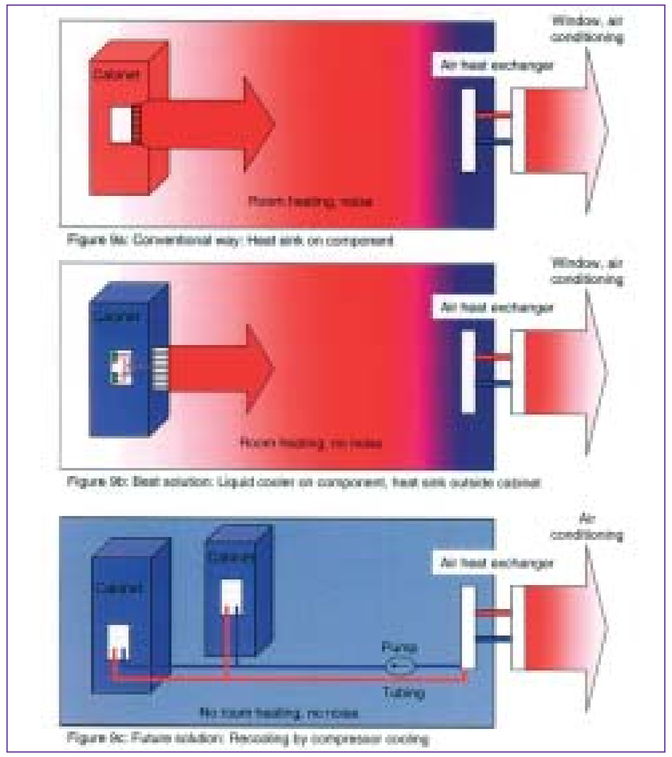

Figure 9a, b, c. Cooling systems.

Figure 8. Liquid cooler with fittings for tube connection.

outside the cabinet (Fig.9b). The temperature inside the cabinet does not increase but the temperature in the room does. In large server units several kilowatts of heat can be generated. Here it makes sense to combine the liquid cooling with compressor or thermoelectric cooling via liquid–liquid heat exchanger as shown in Fig. 9c. This solution is today generally used for re-cooling in power laser diode systems [5]. This advanced solution is now beginning to be introduced in server racks. Small, light-weight liquid coolers are placed onto the CPU's [6]. Fig. 10 depicts a rack system offered by company Rittal. The water is conducted to the re-cooler, which is cooled by compression cooling systems.

The heat generation of active electronic components has increased by orders of magnitude over the past few decades while the physical laws of cooling have not changed. The limits of passive cooling are being reached, or exceeded. New concepts are needed. Liquid cooling is a promising solution, already used in heavy duty industrial applications today.

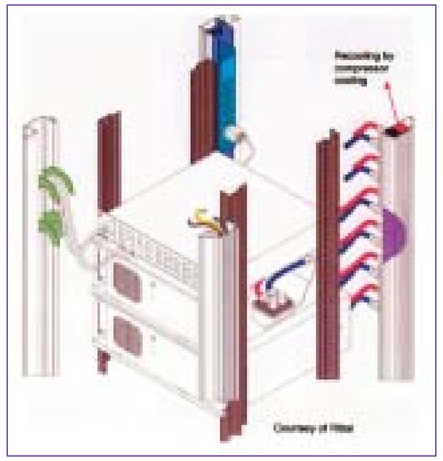

Figure 10. Server rack with liquid cooling.

Literature:

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[2] Dr. Thomas Licht, Dr. Jürgen Schulz-Harder, "Micro channel water cooled power modules" PCIM Power Conversion Intelligent Motion Power Quality Nürnberg June 2000

[3] Dr. Schulz-Harder, Dipl.-Ing. Suavi Örey, "Thermal management of dense power electronics for drives", Power Electronics Europe Issue 3 2002

[4] Ratnesh K. Sharma, "Inkjet assisted spray cooling of electronics", IMAPS Advanced technology workshop (ATW) on thermal management for high-performance computing and wireless applications, October 2003

[5] Thilo Horvatitsch, "Winzlinge mit hohem Potenzial", Laser Issue 4 2001 page 42-44

[6] CWI, "Wasserkühlung für Server", Journal: c't Issue 10 2002

www.curamik.com

200W 48V Field MTBF of Over 1,000,000 Hours

TPower-One introduces the MPU200-1048 ac-dc power supply, providing a 4.2 amp 48VDC output. The 200-watt product has a field MTBF in excess of 1,000,000 hours, based on data compiled from an installed base of over 500,000 similar MPU-Series products, making it an ideal high-reliability power source for telecom, datacom, medical, and industrial applications.

Standard features include: Power Factor Correction (PFC), 85 to 264VAC input range, and active current sharing with N+1 redundancy. An internal isolation diode is optional. The MPU200-1048 comes in a compact 8.00" x 4.20" x 1.50" (203.2 mm x 106.7 mm x 38.1 mm) package that fits inside a 1U chassis height. A DC-input version is also available in this same exact form factor.

Interface signals include: Remote sense, Output Good, Input Power Fail Warning, and Global Inhibit. Internal protections are provided for overtemperature, overcurrent, and overvoltage. Onboard EMI filtering provides Class B compliance to FCC CFR Title 47, Part 15, Sub-Part B - Conducted; and EN55022/CISPR 22 Conducted. Regulatory agency certifications include UL recognition to UL60950/CSA 22.2 No. 60950-00 and TUV approval to EN60950-1.

www.power-one.com

Fluid cooler for power modules

In view of the power density of today's semiconductor components, the dissipation of heat from electronic power modules is an increasingly complex problem. With their product line of innovative "FLK" fluid coolers with a reduced volume, Fischer Elektronik have developed an efficient concept for heat dissipation. Despite the very compact design, these fluid coolers are very efficient, and they are dimensioned to suit existing power modules such as IGBT, thyristor or SCR modules, AC switches, bridge rectifiers etc. The coolers are made from aluminium, and the surface of the base plate is precisely milled to accommodate the semiconductor components. The power modules are directly fastened using existing threaded holes. In addition to this consistently extended standard series, Fischer Elektronik also provide special versions.

www.fischerelektronik.de

Programmable Two-Phase PWM control IC

International Rectifier has introduced the IR3092, an 80A programmable two-phase interleaved pulse width modulation (PWM) control IC to support the AMD Athlon, AMD Athlon64, AMD Opteron, and Intel VR10.X processors. Applications include server and desktop computer motherboards, voltage regulator modules (VRM), video graphics cards and telecom single in-line package (SIP) modules.

The IR3092 is ideal for space-constrained systems with high load current and efficiency requirements. Compared to competitive devices that require external gate drive circuits, the IR3092 includes integrated MOSFET drivers with 3.5A drive capability. Existing two-phase solutions that are implemented with three ICs can now be replaced with a single IR3092 improving system reliability, reducing board area and simplifying circuit design. A patent-pending body braking circuit reduces the output capacitance requirement by up to 25% further reducing system costs.

When combined with IR's DirectFET technology HEXFET MOSFETs, circuit designers can realise a highly efficient, space saving solution with the IR3092.

The PWM control IC operates from a single 12V supply and includes a linear regulator to power the gate drivers. The regulator output voltage can be programmed to minimize switching losses and optimize efficiency. A programmable oscillator, with a frequency range of 100kHz to 540kHz, gives the designer additional flexibility to improve system efficiency and transient response.

Electronica, Munich, 9-12 November 2004, Hall/Stand A5.576

www.lambda-europe.com

New Generation of Ultrafast Recovery Diodes

IXYS announces today the introduction of a new generation of ultrafast recovery diodes called Sonic-FRDTM (DH-series).

The diodes of the Sonic-FRDTM family have a VRRM rating from 600 V to 1800 V with different current values. The first products with this new fast recovery design are available in TO-247 package.

This Sonic-FRDTM diode is ideally suited for power applications from medium to high switching frequencies and high rates of change of current (di/dt), especially hard switching, free wheeling and boost configurations, such as in Uninterruptible Power Supplies (UPS), AC-Inverters with IGBT, Switch Mode Power Supplies (SMPS), Power Factor Correction (PFC) circuits. All of these will benefit from the optimised characteristics of reduced reverse recovery current (IRR) and charge (QRR) as well as a soft recovery with short tail currents that results in reducing the losses in switching transistors, minimizing EMI noise and the need for additional snubber circuitry.

The use of Sonic-FRDTM rectifiers provide the most efficient and highest power density at lower costs.

www.ixys.com

Automatic switching function makes LDO a 'greener' option

Phe XC6207 from Torex Semiconductor Europe is a low noise, high speed, low dropout (LDO) voltage regulator with a difference—it is equipped with a green operation (GO) function that makes it super energy efficient. This provides an extremely attractive solution for a wide range of hand-held and portable equipment applications.

Depending on the load current level, the XC6207 automatically switches between high speed mode and power save mode, efficiently reducing power consumption at appropriate times. In high speed mode power consumption is typically 50µA and in power save mode this falls to 6.0µA. The switch point is fixed internally within the IC. When only high speed operation is required high speed mode can be fixed by inputting a high level signal to the XC6207's GO pin, thus creating operating conditions with the most suitable level of supply current for the application. Standby current is less than 0.1µA (typ).

The green LDO incorporates a voltage reference, error amplifier, current limiter and a phase compensation circuit plus a driver transistor in a single IC. It gives designers a low dropout voltage of 45mV @30mA and fast ripple rejection of 70dB @ 1kHz. The XC6207 is available in a wide range of output voltage ratings, from 0.8V to 5.0V and selectable in 50mV increments. Operating voltage range is 2.0 to 6.0V, maximum output current is 300mA.

The XC6207 is available in SOT-25, SOT-89-5 and ultra compact USP-6B packages. Operational temperature range is –40 to +85°C.

www.torex.co.jp

Companies in this issue

Please note: **Bold**—companies advertising in this issue